THE UNIVERSITY OF ALBERTA

AN EXPERIMENTAL INVESTIGATION COMPARING ATTITUDES TOWARD MATHEMATICS OF MODERN AND TRADITIONAL MATHEMATICS STUDENTS AT THE JUNIOR HIGH SCHOOL LEVEL

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled An Experimental Investigation Comparing Attitudes Toward Mathematics of Modern and Traditional Mathematics Students at the Junior High School Level submitted by Henry Albert Remai in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

The main aim of this study was to determine and compare the attitudes toward mathematics of students studying modern and traditional mathematics at the junior high school level. The auxiliary factors of sex, scholastic ability, and problem solving skill were also investigated to determine their relationship toward attitudes.

In the school term 1962-63, the Junior High School Mathematics subcommittee of the Department of Education in the Province of Alberta initiated an experimental program in modern mathematics at the junior high school level. The experimental group, consisting of 13 classes, studied a modern mathematics program in grades seven, eight, and nine. The texts used were Seeing Through Mathematics and Exploring Modern Mathematics. The control group, consisting of five classes, studied Winston Mathematics and Mathematics for Canadians. A scholastic ability test had been administered to the students in September, 1963, and the experimental and control groups, although not randomly selected, were found to be comparable.

In April, 1965, the students in both groups were given a problem solving test. The eighteen classes were used in this study.

The purpose of this study was to construct and validate an attitude scale. This scale was administered to the above mentioned classes. The hypotheses, which related to attitude, sex, scholastic ability and problem solving skill, were tested by using an one-way and two-way unweighted means analysis of variance and Pearson product-moment correlations.

No significant differences were found between the attitude scale

scores of modern and traditional mathematics students. In the traditional mathematics group, the boys had a significantly better attitude toward mathematics than the girls. No significant difference was found between the attitudes of boys and girls studying modern mathematics. A significant positive relationship exists between the attitudes toward mathematics and scholastic ability, and between attitudes toward mathematics and problem solving skill.

PREFACE AND ACKNOWLEDGEMENTS

The purpose of this study was to investigate and compare the attitudes toward mathematics of modern and traditional mathematics students at the Junior High School level. The subsidiary factors of scholastic ability and sex were also considered.

The writer wishes to express his sincere appreciation to Dr. S. E. Sigurdson for his constructive guidance and encouragement during the course of this investigation.

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H.A.R.

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THE NATURE OF THE PROBLEM

INTRODUCTION

The popularity of the time-worn phrase "readin', ritin', and 'rithmetic" does not stem from the alliteration alone. These are still considered the indispensable tripod on which an education must rest if we are to cope successfully with the demands of our complex society. However, the meaning of what these three basic fundamentals entail has changed over the years, especially in the field of arithmetic and mathematics.

Mathematics is the only branch of learning in which all the major theories of two thousand years ago are still valid; yet never before has there been such a flood of fresh ideas. As a concomitant result of these discoveries in mathematics, the horizons of science and technology have been extended. Consequently, technology invades our homes to a greater extent than ever before. There are fewer and fewer places open to the mathematically illiterate. This situation caused Banks[1] to say:

> The great paradox of this age is the fact that as our culture becomes more and more technical - more mathematical - a continuously decreasing percentage of our population is receiving mathematical training.

Another writer, directing his comments to the same problem states:

> The world of today demands more mathematical knowledge on the part of more people than the world of yesterday and the world of tomorrow will make still greater demands. Our society leans

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[1] J. H. Banks, Learning and Teaching Arithmetic, (Boston: Allyn and Bacon, 1959), p. 3.

> more and more heavily on science and technology. The number of our citizens skilled in mathematics must be greatly increased; and understanding of the role of mathematics in our society is now a prerequisite for intelligent citizenship. Since no one can predict with certainty his future profession, much less foretell which mathematical skills will be required in the future by a given profession, it is important that mathematics be so taught that students will be able in later life to learn the new mathematical skills which the future will surely demand of many of them.[2]

This accelerated growth in both mathematics and its wide range of application has in turn generated a host of curricular experiments inspired by the notion that children can learn more or better mathematics than they have in the past. A survey of improvement programs for school mathematics[3] gives a brief description of twenty-seven mathematics programs ranging from kindergarten to college level. The most basic common ground underlying these various groups is their objective to offer students not only the basic mathematical skills but also a deeper understanding of the basic concepts and structure of mathematics.

In evaluating these new materials, several questions must be considered. How do the students feel about these new materials in comparison to the conventional subject matter? What are the differences between the modern and traditional materials in regard to scope and content? What is the comparative achievement of modern and traditional mathematics students?

These and more are the interesting and important questions that can be asked, and that need to be answered if we are going to evaluate

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[2]School Mathematics Study Group, Newsletter No. 4, March, 1960 (New Haven: Yale University, 1960), p. 3.

[3]Studies in Mathematics Education, (Scott, Foresman and Co.), Summer, 1960.

the new mathematics materials.

STATEMENT OF THE PROBLEM

Do students taking modern mathematics possess a more favorable attitude toward mathematics than their counterparts enrolled in traditional courses? Is there a positive relationship between scholastic ability and attitude toward mathematics? Do boys and girls feel the same way about mathematics? Is there a significant positive correlation between problem solving skill and attitude toward mathematics? The writer will investigate the above questions.

The specific problem is to determine whether students enrolled in a modern mathematics course possess a more favorable attitude toward mathematics than students taking traditional mathematics. The subsidiary factors such as sex and scholastic ability will also be considered to determine if they are variables which indicate significant differences in attitude toward mathematics.

SCOPE OF THE PROBLEM

In the school term 1962-63, the Alberta Junior High School Mathematics Subcommittee started an experimental program with modern mathematics at the junior high school level. The experimental group would take modern mathematics in grades seven, eight, and nine. The control group would continue with conventional (traditional) mathematics in these grades. At present, within the scope of the experimental program at the grade nine level, there are three hundred and thirty-one students in the experimental group and one-hundred and twenty students in the control group.

The experimental group consists of students using three different kinds of modern mathematics programs. The largest group, consisting of seven classes and involving one hundred and eighty-four students, use as their texts Seeing Through Mathematics, Books 1 and 2 (STM).[4] The other major text, Exploring Modern Mathematics, Books 1 and 2 (EMM)[5] is used by four classes comprising ninety-eight students. The remaining two classes in the experimental group consists of forty-nine students who used the STM texts in grades seven and eight and the EMM texts in grade nine. The control group consisting of one-hundred and twenty students in five classes used the Winston Mathematics, Books 1 and 2[6] in grades seven and eight, and the traditional text-book, Mathematics for Canadians, Book 1[7] in grade nine.

The students involved in this experimental program had been tested by the Subcommittee or by people associated with it at the grade seven, eight and nine level. The Cooperative School and College Ability Test (SCAT) had been administered to them in September 1963. On the basis of

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[4]Henry Van Engen and others, Seeing Through Mathematics, Book 1 (Canadian edition; Toronto: W. J. Gage Ltd.) 2 parts; and Henry Van Engen and others, Seeing Through Mathematics, Book 2, (Chicago: Scott, Foresman and Company, 1962), 2 parts.

[5]Mervin L. Keedy, Richard E. Jameson, and Patricia L. Johnson, Exploring Modern Mathematics, Book 1 (New York: Holt, Rinehart and Winston, Inc., 1963); and Mervin L. Keedy, Richard E. Jameson, and Patricia L. Johnson, Exploring Modern Mathematics, Book 2 (New York: Holt, Rinehart and Winston, Inc., 1963).

[6]H. L. Stein and others, Winston Mathematics, Intermediate I (Toronto: The John C. Winston Company, Limited, 1954, 1957); and H. L. Stein and others, Winston Mathematics, Intermediate 2 (Toronto: The John C. Winston Company, Limited, 1954, 1957).

[7]Henry Bowers, Norman Miller, and Robert E. K. Rourke, Mathematics for Canadians, Book 1, (J. M. Dent and Sons (Canada) Ltd., and The Macmillan Company of Canada Limited, 1947.)

this, it was found[8] that the groups of students studying the different textbooks were fairly well matched as to scholastic ability.

SIGNIFICANCE OF THE PROBLEM

In recent years numerous studies have been carried out comparing the achievement of students enrolled in traditional and modern mathematics courses. Unfortunately, most of these studies have made only a passing reference to the place of attitudes in mathematics education. They have overlooked the area of student attitudes which might be developed so students will not only continue their education in mathematics, but will also gain the maximum benefit from each class. Johnson[9] shows his concern about the lack of attention paid to attitudes when he states:

> In our concern for improving the mathematics curriculum and increasing enrollment in mathematics, have we forgotten a crucial factor, namely attitudes? Have we forgotten that learning involves emotional vectors such as attitudes? It is the attitudes that our students develop which are likely to stimulate or to stop further study of mathematics. It is the attitudes which we build that are highly involved in the learning and retention of our subject.

Ragan[10] points out that evaluation should not only be concerned with academic achievement but with attitude development as well since the child's attitudes affect what he learns, what he remembers, what he thinks, and what he does.

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[8] B. Harrison, "An Analysis of the Effectiveness of Three Mathematics programs at the Grade Eight Level" (Unpublished Master's Thesis, University of Alberta, Edmonton, 1964) p. 59.

[9] Donovan A. Johnson, "Attitudes in Mathematics Classrooms," School Science and Mathematics, 57, 1957, pp. 113-116.

[10] W. B. Ragan, Modern Elementary Curriculum, (New York: Dryden Press Inc., 1953), p. 496.

In doing an analysis of new mathematics programs, The National Council of Teachers of Mathematics[11] states:

> For our purpose, we must assume that program changes are aimed at improving the achievement of the following objectives: developing greater computational skill, developing the ability to think mathematically, developing insight into the structure of mathematics, developing favorable attitudes toward mathematics.

From this it would seem,that one of the aims of the new mathematics program is to improve the situation described by Dutton[12] in his study of student attitudes toward traditional mathematics at the junior high school level. He found that nineteen percent expressed extreme dislike of mathematics. Other research in this area has produced similar results.

In the Alberta Study, most comparisons between modern and traditional mathematics students have been mainly concerned with the achievement aspect, no attempt has been made to determine if modern mathematics students develop a more favorable attitude toward mathematics than their counterparts in the traditional courses.

DELIMITATIONS

Due to the conditions and circumstances under which the study was conducted, several limitations exist. These will be commented on briefly.

The influence that a teacher may have in determining student attitude is not considered in this study. Any variations resulting from

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[11] National Council of Teachers of Mathematics, An Analysis of New Mathematics Programs, 1964, p. 37.

[12] W. H. Dutton, "Attitudes of Junior High School Pupils Toward Arithmetic," School Review, 64 18-22 , January1963.

such influence should be minimized since the eighteen classes involved in the study were taught by fourteen different teachers. This means that no one particular teacher could influence the attitudes of a large proportion of the population being used.

In much experimental research it is inconvenient if not impossible to obtain samples of equal size. Since Winer[13] states it is not essential that the experimental and control samples be of equal size, the fact that modern students outnumber traditional students by 331 to 120 is not considered to be of major consequence.

The attitude scale used in this study is based on the assumption that students did freely and honestly express their opinions about mathematics. Guilford[14] states that attitudes can be measured by the opinions that individuals endorse as their own and that opinions can be calibrated. Thurstone,[15] who has done considerable research in attitude measurement, says,

> All that we can do with an attitude scale is to measure the attitude actually expressed with the full-realization that the subject may be consciously hiding his true attitude or that the social pressure of the situation has made him really believe what he expresses. This is a matter for interpretation. It is probably worthwhile to measure an attitude expressed by opinions. It is another problem to interpret in each case the extent to which the subjects have expressed what they really believe. All that we can do is to minimize as far as possible the conditions that prevent our subjects from telling the truth, or else to adjust our interpretations accordingly.

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[13]B. J. Winer, Statistical Principles in Experimental Design, (New York: McGraw-Hill Book Co., 1962), p. 96

[14]J. P. Guilford, Psychometric Methods, (New York: McGraw-Hill Book Co., 1954), p. 457.

[15]L. L. Thurstone and E. J. Chase, The Measurement of Attitude (The University of Chicago Press, 1929), p. 10

Since Guilford[16] states, "while attitudes are subject to change, their direction and strengths are sufficiently enduring over periods of time to justify treating them as personality traits;" the fact that the investigator was unable to control any possible effects on attitude resulting from homework, examinations, and the like which may have been given a day or several days before the students completed the attitude questionnaire, is not considered to be of prime importance.

No attempt has been made to control the variations or determine the resulting influence that probably exists in the quality of instruction, in the philosophy of the various homes and communities, and in the students themselves. The effect of such variations of individuals should be reduced when the data from the group made up by the individuals is treated statistically. Thus acceptable measures of group performance are obtained as stated by Wert, Neidt, and Ahmann.[17]

> The inability to obtain precise measures of human characteristics is a limiting factor whenever the purpose is for counseling an individual, but is a consideration of less importance in research studies involving groups of individuals. Generalizations may be drawn concerning group reaction which are entirely tenable for a group but which would be extremely dubious if applied to any individual within the group.

CLARIFICATION OF TERMS

Several of the terms which might cause confusion for the reader are defined as follows:

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[16] J. P. Guilford, Psychometric Methods (New York: McGraw-Hill Book Co., 1954), p. 457.

[17] J. E. Wert, C. E. Neidt, and J. S. Ahmann, Statistical Methods in Educational and Psychological Research, (New York: Appleton-Century-Crofts, 1954), p. 2.

Modern (New) Mathematics refers to school mathematics materials that convey the spirit and recommendations of contemporary mathematics curricular reform groups. In these materials, emphasis is placed upon the meaning and understanding of fundamental concepts.

Traditional (Conventional) Mathematics is used to refer to the approach to the teaching of school mathematics that has not stressed the structure and fundamental concepts of the subject and has relied largely on the teaching of rules.

Mathematics refers to the group of sciences (arithmetic, geometry, algebra) dealing with quantities, magnitudes, forms and their relationships and attributes.

Higher Ability Group refers to those students in the experiment who obtained SCAT total scores of 96 or above.

Average Ability Group refers to those students who obtained SCAT total scores greater than 84 and less than 96.

Low Ability Group refers to those students who obtained SCAT total scores of 84 or less.

Control group refers to those students in the experiment who are studying traditional mathematics materials.

Experimental group refers to those students in the experiment who are studying modern mathematics materials.

PREVIEW OF THE THESIS

The present chapter introduces the problem as well as giving the scope and limitations of the study. Chapter II gives a description of the nature of attitude and representative student behavior. Chapter III

consists of a report of the literature related to this project. The design of the research, statistical procedures, and a description of the measuring instruments used appear in Chapter IV. Chapter V contains a presentation of the data and an analysis of the results obtained. Chapter VI summarizes the findings and conclusions of the study. Implications for further research arising out of this study are also stated in the last chapter.

CHAPTER II

THEORETICAL FRAMEWORK

INTRODUCTION AND EXPLANATION

The writer, in searching for a suitable definition of the term attitude, found that there appears to be as many definitions for it as there are writers on the subject. Rhine[1] states that a single meaning of attitude upon which there is close agreement is not available. This gives some indication of the complexity of the term. The meaning of attitude as expressed in the context of Krathwohl's[2] taxonomy was accepted as the criteria for this study. Since no all inclusive definition of attitude is given, a brief summary of the taxonomy is included with stress being placed on attitude development.

Many educational objectives are stated in such a manner that they are meaningless to the educators who are trying to achieve them. To remedy this situation Krathwohl[3] developed a large over-all scheme into which the educational objectives could be placed. The purpose of placing the objectives within the classification scheme was to position them on a continuum and thus serve to indicate what was intended as well as what was not intended by each objective. This would also help to clarify the

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[1] Raymond J. Rhine, "A Concept Formation Approach to Attitude Acquisition," Psychological Review, 65:362-370, 1958.

[2] David R. Krathwohl, Benjamin S. Bloom, and Bertram B. Masiu, Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook II: Affective Domain (New York: David McKay Company, Inc., 1956).

[3] Ibid.

language of educational objectives by stabilizing the meaning of various terms.

Internalization was selected as the organizing principle for the taxonomy since it helps delimit, describe, and classify objectives into the desired structure. It describes a process whereby a given phenomenon passes from a level of bare awareness to a position where it guides and controls the behavior of a person. Internalization is analagous to an old education axiom that states "growth occurs from within."

Internalization refers to this inner growth which takes place as the individual accepts attitudes, codes, principles, or sanctions that become a part of him in forming value judgments or in determining his conduct. This growth takes place in different ways. One of these ways is the increased emotional impact of the experience. At the lowest levels of the internalization continuum there is little emotion in the behavior since the individual is merely perceiving the object. At the middle levels, emotional response is a recognized and critical part of the behavior as the individual actively responds for the emotion that is experienced determines the type of overt behavior. This emotion decreases as the behavior becomes completely internalized and routine.

This growth along the continuum may also be traced by the relationship between external and inner control. At the lowest levels of the continuum inner control merely directs attention. At middle levels, inner control produces the proper responses at the bidding of an external force. At the highest levels, inner control produces appropriate responses in the absence of an external force.

The titles of the categories imply this change in direction of

control and emotion. A lower level is titled "Responding," thus indicating that the individual is reacting to an inner control with some emotion. The next level, "Valuing," indicates that the control is becoming more internalized with more emotion involved. However, in the next two categories, the emotional component decreases but the inner growth continues to become more completely internalized.

Many of the common educational affective terms are used in educational objectives with a wide range of behavior indicated. Thus, in the taxonomy, we have an overlap in their range of interpretation. The term "attitude" in educational objectives ranged from situations where it is used to describe the involvement of the student who is willing to grant that he has a positive feeling about something when he is asked it, to situations in which he goes out of his way to display the value or communicate it to others. When we speak of an individual as holding a value, the same range of behaviors as described for attitudes comes into play.

The term "appreciation," like "interest" may refer to such a simple behavior as a person being aware of an object or phenomenon and being able to perceive it. This would denote behaviour at the lower level of the continuum. If the appreciation and interest is such that it causes the individual to respond voluntarily to a situation, and if a measure of satisfaction is obtained from this activity; then this denotes behaviour at the middle of the continuum. The overlap indicates that no one term alone can adequately define the continuum at that point and signifies an interrelationship among the various terms.

TABLE I

THE RANGE OF MEANING TYPICAL OF COMMONLY USED AFFECTIVE TERMS MEASURED AGAINST THE TAXONOMY CONTINUUM

1.0 RECEIVING	1.1 AWARENESS					
	1.2 WILLINGNESS TO RECEIVE					
	1.3 CONTROLLED OR SELECTED ATTENTION					
2.0 RESPONDING	2.1 ACQUIESCENCE IN RESPONDING					
	2.2 WILLINGNESS TO RESPOND				APPRECIATION	INTEREST
	2.3 SATISFACTION IN RESPONSE					
3.0 VALUING	3.1 ACCEPTANCE OF A VALUE			ATTITUDES		
	3.2 PREFERENCE FOR A VALUE		VALUE			
	3.3 COMMITMENT	ADJUSTMENT				
4.0 ORGANIZATION	4.1 CONCEPTUALIZATION OF A VALUE					
	4.2 ORGANIZATION OF A VALUE SYSTEM					
5.0 CHARACTER-IZATION BY A VALUE COMPLEX	5.1 GENERALIZED SET					
	5.2 CHARACTERIZATION					

THE CLASSIFICATION SCHEME

A compendium of the categories and sub-categories through which attitude extends on the continuum follows. Also, representative student behavior will be indicated at the respective levels.

2.0 RESPONDING

This differs from receiving in that the student is not only willing to receive or to attend to a certain stimuli, but is actively engaged. The student is committing himself in a small measure to the phenomena involved.

2.1 ACQUIESCENCE IN RESPONDING

This does not fall in the range of the interpretation of attitude behavior since compliance describes the student's behavior. Although the student makes the required response, he has not fully accepted the necessity for doing so. This could apply to the completion of homework.

2.2 WILLINGNESS TO RESPOND

The main difference between this level and the preceding one is that the teacher no longer has to exert pressure on the student to perform. The student acts on a voluntary basis and not out of a fear of punishment.

The student responds with consistent, active,and deep interest to intellectual stimuli. He contributes to group discussion by asking thought-provoking questions or supplying relevant information and ideas. His behavior is polite and of a co-operative nature. His assignments and reports are always carefully and neatly completed. Frequently he goes beyond the minimum requirements of the assignment. He is among the first to hand in his assignment or complete his work. This is based on the

assumption that the earlier the assignment is turned in, the greater the likelihood that it was done willingly.

Making an inference of willingness to respond based on only one of the above cues is fraught with error. Instead, we must look for a whole series of cues which, when woven together, possess an internal consistency and increases the probability that an interpretation of willingness to respond is warranted.

At this level it is not necessary to ascertain the reasons for the willingness to respond. Whether the student responds willingly in order to please the teacher, or because he is intrigued with the subject need not concern us, since in either case the student has a positive orientation toward the subject. At this level, pleasing the teacher can be a motive for learning that has intrinsic worth for the student. The teacher's use of her influence as a positive factor is one of her major tools for working in the affective domain above the 2.1 level. This means the student's perception of the teacher's feelings for the subject he teaches is going to be of prime importance. It is highly unlikely that a student will develop a favorable attitude toward a subject when he feels his teacher dislikes it.

2.3 SATISFACTION IN RESPONSE

The additional element in the step beyond willingness to respond is that the behavior is accompanied by a feeling of satisfaction, an emotional response, generally of pleasure, zest, or enjoyment.

It is vital to recognize that satisfaction and emotionality of response are certainly a part of the upper subcategories of the category above this, namely 3.0 Valuing. Yet the lowest level of valuing -

acceptance of a value - need not necessarily be accompanied by emotion. Having an opinion may mean that one has a belief that is held without emotional commitment or desire; one that is open to re-evaluation, since the evidence is not sufficient to be convincing. Also, willingness to respond may be accompanied by a low level of emotionality, possibly of enthusiasm. Thus, the attempt to specify a given position in the continuum as the one at which the emotional component is added is impossible. However, the category is arbitrarily placed at this point in the hierarchy where it seems to occur most frequently.

Student behavior characteristic of this level is varied. The learner finds pleasure in doing mathematical puzzles and number games. He will read magazines and books about mathematics voluntarily if the opportunity to do so is present. The student will study mathematics because he enjoys it. He gets satisfaction from knowing mathematical ideas and he feels rewarded when he attains mathematical competency. The student who appreciates the order and logic of mathematics will get satisfaction out of an elegant proof. If the students are to learn to like mathematics they must find pleasure in performing the learning activities in and out of the mathematics classroom. The learners will find pleasure in doing that which they can do successfully, and that which seems significant in meeting their needs.

3.0 VALUING

This category gives more specificity to the term value than is present in its ordinary usage in that it defines three levels of valuing, each representing a stage of deeper internalization. At this level, we are not concerned with the relationship among values but rather with the

internalization of a set of specified values.

Behavior at this level is sufficiently consistent and stable to have taken on the characteristics of a belief. The learner displays this behavior with sufficient consistency that he comes to be perceived as holding a value. An important aspect of behavior characterized by valuing is that it is motivated, not by the desire to comply or obey, but by the individual's commitment to the underlying value guiding the behavior.

3.1 ACCEPTANCE OF A VALUE

At this level, the student is consistent enough in his responses that he is perceived by others as holding the value or belief. Also, he is willing to be so identified. However, his belief is rather tentative and he is willing to re-evaluate his position.

The learner exhibits a continuing desire to learn to develop his mathematical ability. He seeks out friends interested in mathematics and discusses it with them outside of regular school hours. He appreciates the role mathematics plays as an important factor in the development of our society and in our daily lives.

3.2 PREFERENCE FOR A VALUE

Behavior at this level implies not just the acceptance of a value to the point of being willing to be identified with it, but the individual is sufficiently committed to the value to pursue and seek it out. The student fosters his special interests within a given area of the curriculum. He shows a preference for these values or interests over others. This will be indicated by consistency in his behavior and his particular point of view. In regard to mathematics, he will have a keen curiosity about the unique structure of mathematics and a continuing

desire to understand this structure. He will detect weaknesses in proofs lacking a logical order and suggest improvements as well as alternative solutions.

3.3 COMMITMENT

The person who displays behavior at this level is clearly perceived as holding the value. He acts to further the thing valued in some way, to extend the possibility of his developing it, to deepen his involvement with it and with the things representing it. He tries to convince others and seeks converts to his cause. He has a firm emotional acceptance of a belief or value which may be held on nonrational grounds. To test for behavior at this level, we must consider the amount of time and energy invested by the student in behalf of the value he holds. There should be evidence that the actions taken in the pursuing of the valued object satisfies a need within the individual.

4.0 ORGANIZATION

At this level, the learner has internalized values to the point where he encounters situations for which more than one value is relevant. He is faced with the task of determining the interrelationship among his various values and organizing them into a consistent system.

4.1 CONCEPTUALIZATION OF A VALUE

This subcategory involves the quality of abstraction. It permits the individual to see how a value he is becoming to hold relates to those he already had. This involves the application of the value to a wider set of data or phenomena than that from which it was originally obtained.

Student behavior at this level is characterized by evaluative judgments about the role of mathematics in music, architecture, and the

practical aspects of everyday life such as business activities, taxation, insurance, and budgeting. He uses mathematics as a means of explaining his environment, explaining design, and so on.

In summary, the purpose of the taxonomy was to provide a classification for educational objectives which would yield a continuum and which would stabilize the meaning of common educational affective terms. The organizing principle which produced this desired structure was internalization. On this continuum, attitude has a close interrelationship with the terms appreciation, interest, and value.

CHAPTER III

REVIEW OF SELECTED RELATED LITERATURE

INTRODUCTION

Most of the literature on attitudes can be organized around three basic approaches. One approach explains attitudes in terms of the influence of success and failure experiences in arithmetic and mathematics. The literature related to this approach is reviewed separately at the elementary and junior-senior high school level. Another approach considers teachers and parents to be of primary influence in the development of student attitudes. A third is mainly concerned with the role played by personality factors and sex differences in determining attitudes toward mathematics in general and toward problem solving. In addition, a summary of the major techniques used in attitude scale construction is included. Also, a detailed review of literature comparing attitudes of traditional and modern mathematics students is presented.

ELEMENTARY SCHOOL LEVEL

Stright[1] used an adapted form of Dutton's attitude scale to compare the attitudes of both children and teachers toward arithmetic in grades three, four, and six. She found a decline from grade three to six in the per cent of students expressing unfavorable reactions to

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[1]Virginia M. Stright, "A Study of Attitudes Toward Arithmetic of Students and Teachers in the Third, Fourth and Sixth Grades," The Arithmetic Teacher, 7:280-286, January 1960.

arithmetic. This may represent a real change or merely acceptance of verbalisms to the effect that it is good for them. Contrary to common belief, girls in all three grades liked arithmetic better than boys, and twenty-two per cent more of the girls thought everyone should know arithmetic. From grade three responses to the scale, she concludes that definite attitudes, for and against arithmetic, have developed by the third grade.

Her data on the teachers indicates the majority of them enjoy teaching arithmetic. This does not mean they are good teachers of this subject. She also found the teachers' educational background, recent training, age, and experience seemed to make no difference in their attitude toward teaching of arithmetic, nor of the attitude of the children in the group.

Fedon[2] also found definite attitudes expressed by third grade pupils for and against arithmetic. He used a revised form of the Dutton scale and a color scheme to indicate the choices as to likes and dislikes. Unfortunately, his subjects consisted of only one grade three class.

A study to determine the effect on attitudes of twenty-one periods of planned instruction in three fourth grade arithmetic classes was carried out by Lyda and Morse.[3] They administered the Dutton Attitude Scale, the Stanford Arithmetic Achievement Test, and the Otis Mental

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[2] J. Peter Fedon, "The Role of Attitude in Learning Arithmetic," The Arithmetic Teacher, 5:305-310, December, 1958.

[3] Wesley J. Lyda, and Evelyn Clayton Morse, "Attitudes, Teaching Methods and Arithmetic Achievement," The Arithmetic Teacher, 10:136-138, March, 1963.

Ability Test both before and after the special instruction, with alternate forms of the latter two used in the pre and post testing. They found a marked trend toward positive attitudes toward arithmetic among all three classes.

Faust[4] was interested in determining the relationship between teacher and pupil attitude toward a subject and student achievement in this subject. He used a paired comparison type of instrument. Each of the eleven subjects were paired with every other subject. Pupils indicated the subject of each pair they liked best. In analyzing his data, he only used the results from arithmetic, spelling, reading, and language. He stated his two main conclusions as follows:

> (1) The relationship between teacher attitude and pupil achievement was higher for departmental teachers than non-departmental teachers in all subjects except arithmetic.
> (2) Relationship between teacher, and pupil attitude toward school subjects tend to be high. In many cases, there was a close agreement between the attitude of a teacher toward a subject, and the attitudes of the class. Especially so between the special teachers in arithmetic and their pupils in the school where departmental teaching was used.

In trying to determine the effect of grouping in arithmetic and attitude towards it, Lerch[5] concludes there is no significant difference in attitude toward arithmetic between the experimental and control groups. He suggests the child's successes in arithmetic and his attitudes toward it are more basically dependent upon his teachers' attitudes and the methods

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[4]Claire Edward Faust, "A Study of the Relationship Between Attitude and Achievement in Selected Elementary School Subjects," (Doctoral Dissertation, State University of Iowa, August, 1962), p. 109.

[5]Harold H. Lerch, "Arithmetic Instruction Changes Pupils' Attitudes Toward Arithmetic," <u>The Arithmetic Teacher</u>, 8:117-119, March, 1961.

they employ than they are upon classroom organization.

Bassham, Murphy and Murphy[6] investigated the relationship between pupil attitude toward arithmetic and student achievement in the subject. Unexpectedly, they found only a slight positive relationship between the two. In this study, the test conditions varied. The school counsellor administered the instruments to two of the classes while the regular classroom teachers did this in the other three grade six classes involved in the study.

A study dealing with children's reactions to a televised arithmetic program was conducted by Kaprelian.[7] Two, fifteen minute telecasts were shown to sixty-five grade four students weekly. On a questionnaire, seventy-seven per cent said they liked arithmetic better now because they understood it better. However, the pupils felt they needed more teacher aid and direction when the subject was presented by television than when it was learned in the conventional classroom situation.

The writers, Cooke,[8] Wilson,[9] Alley[10] and Gough,[11] express

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[6]Harold Bassham, Michael Murphy, and Katherine Murphy, "Attitude and Achievement in Arithmetic," The Arithmetic Teacher, 11:66-72, February, 1964.

[7]George Kaprelian, "Attitudes Toward a Television Program - Patterns in Arithmetic," The Arithmetic Teacher, 8:408-410.

[8]Ralph J. Cooke, "Helping Children Build a Positive Attitude Toward Arithmetic Through Its Mathematical Concepts," School Science and Mathematics, 54:197-211, March, 1954.

[9]Guy M. Wilson, "Why Do Pupils Avoid Mathematics in High School?" The Arithmetic Teacher, 8:168-171, April, 1961.

[10]Elizabeth M. Alley, "Building An Appreciation of Mathematics." The Mathematics Teacher, 48:274-275, April, 1955.

[11]Sister Mary Fides Gough, O.P., "Mathemaphobia: Causes and Treatments," Clearing House, 28:290-294, January, 1954.

concern, in separate articles, about pupils attitudes toward arithmetic. Their reports are based on personal observations and observations of others. The following quotation gives the main thought expressed in all of them.

> In particular, it is well known that repeated successful experiences with mathematics may lead to favorable attitudes, and similarly, repeated experiences which are unsuccessful and unsatisfying is likely to lead to the development of an unfavorable attitude toward the subject....Successful experiences contribute to the building up of attitudes favorable to the task, and of interests in it, while failure contributes to unfavorable attitudes toward the experience and inhibits the development of interest in it.[12]

The above studies indicate attitudes toward arithmetic develop as early as grade three. They found no evidence to support the commonly held belief that boys like arithmetic better than girls. These studies found a positive relationship between understanding the subject matter and having positive feelings toward it.

JUNIOR-SENIOR HIGH SCHOOL LEVEL

One of the first to sample pupil attitudes at the junior high school level was Dutton.[13] He administered a twenty-two item Thurstone-type scale designed to determine pupil attitude toward arithmetic. His

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[12]The National Council of Teachers of Mathematics, The Learning of Mathematics, Its Theory and Practice, Twenty-first Yearbook, 1953, p. 56.

[13]Wilbur H. Dutton, "Attitudes of Junior High School Pupils Toward Arithmetic," School Review, 64:18-22, January, 1956.

subjects were four hundred and fifty-nine junior high school pupils, varying from high to low ability. The girls showed a little more dislike for arithmetic than boys, and nineteen per cent of all the students indicated extreme dislike for the subject. The main causes of dislike for arithmetic were lack of understanding, poor achievement, and difficulty in working problems. Students emphasized practicality, interest, and challenge of arithmetic as the reasons for liking it. About one-third of the pupils recognized changes in their attitudes, either favorable or unfavorable, during one or two years in junior high school.

A study by Stephens[14] was made to compare the attitudes of two accelerated, two regular, and two remedial classes in each of the grades seven and eight. The conclusions reached in this study were that there is a highly significant difference in attitude toward mathematics between the accelerated groups and those in the regular groups. There was no significant difference between the regular and remedial groups nor between the accelerated and remedial groups. This may have been caused by the special attention the remedial group received, or perhaps they didn't give the attitude scale serious consideration and marked the more positive items to gain attention. She suggests the attitude scale measurement be used in conjunction with other criteria to determine class placement. This attitude measurement could be used effectively in borderline cases.

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[14]Lois Stephens, "Comparison of Attitudes and Achievement Among Junior High School Mathematics Classes," The Arithmetic Teacher, 5: 351-356, November, 1960.

Malone and Freel[15] state, "A wholesome attitude toward arithmetic is promoted when the child feels (1) that arithmetic is useful, (2) that success for him is possible, (3) that the teacher is enthusiastic about the subject." They tested eight hundred three high school students with a Likert-type attitude scale. The results indicate that students generally realize the importance and practical value of mathematics. They found no significant grade change in attitude toward mathematics from grade nine to twelve. The large number of no opinion responses to questions involving criticism of parents, teachers, and the school indicates a reluctance on the part of the students to disagree with these people. This suggests the need for a different technique.

The attitudes toward school, toward achievement, and toward an education, of two hundred elementary and high school pupils selected to represent certain achievement ability patterns were studied by Kurtz and Swenson.[16] They found these attitudes to be more closely related to the students' achievement scores than to their ability (intelligence test) scores. The same study showed considerable agreement in the attitudes of parents, teachers, and children.

A study concerned with the effects of accelerated and enriched mathematics programs at the junior high school level upon attitude and

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[15] William H. Malone, and Eugene L. Freel, "A Preliminary Study of the Group Attitudes of Junior and Senior High School Students Towards Mathematics," Journal of Educational Research, 47:599-608, April, 1964.

[16] John J. Kurtz, and Esther J. Swenson, "Students, Parent, and Teacher Attitude Toward Student Achievement in School," School Review, 59: 273-279, May, 1951.

achievement was conducted by Ray.[17] Students taking the enriched work with written and oral reports felt they had a better chance to express their ideas about mathematics. All groups experienced some positive attitude change toward mathematics, but the author did not check for differences among the various groups.

In discussing recreational mathematics, Brandes[18] states, "In the hands of a competent teacher it can serve as an instrument to favorably change the attitudes of children toward the mathematics subject." Tulock[19] claims one of the ways to develop favorable attitudes toward mathematics is to make effective use of puzzles, number games, and etc. Proctor[20] used various number games for drill purposes with slow learners. She had girls learn geometric figures by having them make various styled collars out of white paper.

Harris,[21] a British writer, feels that in the teaching of mathematics it is very important that the emotional aspects of learning are not

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[17] John James Ray, "A Longitudinal Study of the Effects of Enriched and Accelerated Programs on Attitude Toward and Achievement in Eighth Grade Mathematics and Ninth Grade Algebra." (Unpublished Doctoral Dissertation, Indiana University, 1961.)

[18] Louis Grant Brandes, "Recreational Mathematics As It May Be Used With Secondary School Pupils," School Science and Mathematics, 54:383-393, 1954.

[19] Mary K. Tulock, "Emotional Blocks in Mathematics," The Mathematics Teacher, 50:522-526, December, 1957.

[20] Amelia D. Proctor, "A World of Hope - Helping Slow Learners Enjoy Mathematics," The Mathematics Teacher, 58:118-122, February, 1965.

[21] Roy Harris, "Psychological Aspects of Teaching Mathematics," Mathematics Teaching, 25:21-27, Winter, 1963.

overlooked, Of all the subjects, mathematics is most likely to create frustration and concomitant emotional reactions which may evolve into a phobia for the subject. In commenting further, he says,

> Mathematics should not be taught according to some monotonous routine. Instead it should be taught in a stimulating and provocative manner. It is in this way that the learning of mathematics will be associated with enjoyment in the pupil's mind and he will look forward to the lessons in this subject. A happy emotional climate must be maintained within the mathematics period. If this is done, then there is every possibility that the pupils will derive a great deal of pleasure from their learning, and that frustration and negative attitudes will be eliminated.[22]

These studies cite lack of understanding and poor achievement as the two major causes for disliking arithmetic. Also, it was found that attitudes are more closely related to achievement than to mental ability. Several writers stress the importance of the role of recreational mathematics in developing favorable attitudes toward mathematics.

PARENTS - TEACHERS

In a study by Dutton,[23] written statements of attitudes toward arithmetic were collected from two hundred eleven prospective elementary school teachers. Of these, only twenty-six per cent of the statements were favorable to arithmetic, and seventy-four per cent were unfavorable. The language used was expressive and emotional, revealing deep-seated attitudes that had persisted from childhood. Prominent among the causes given for the unfavorable attitudes were lack of understanding, failure

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[22] Ibid., p. 25.

[23] Wilbur H. Dutton, "Measuring Attitude Toward Arithmetic," Elementary School Journal, 55:24-31, September, 1954.

to provide enough application to life and social usage, poor teaching techniques, poor motivation, and feelings of inferiority and insecurity. Some of the statements (my parents never could do mathematics) clearly revealed that these students had been influenced by the attitudes of their parents. The main reasons for the favorable attitudes were proficiency in arithmetic, good teachers who explained the work and made it meaningful, and a challenging experience.

In another study, Dutton[24] devised an attitude scale from statements about mathematics he had collected over the past five years from the students in his methods classes. He tried the scale out on two hundred eighty-nine college students of whom twenty-eight were males. The importance of arithmetic and enjoyment derived from it were cited as the major reasons for favorable attitudes, The unfavorable attitudes were caused by feelings of insecurity and lack of understanding. From student indications, it appears that grades three and six are crucial for attitude development. However, it must be remembered that this information was obtained on the basis of the students own memory which is not likely to be entirely reliable, especially concerning the earliest school years.

In broadening the scope of his research, Dutton[25] attempted to determine if the attitudes of the students in his arithmetic method courses in 1962 differed from those in 1954. In comparing the student responses on the same attitude scale he found they were almost identical,

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[24] Wilbur H. Dutton, "Measuring Attitude Toward Arithmetic," Elementary School Journal, 55:24-31, September, 1954.

[25] Wilbur H. Dutton, "Attitude Change of Prospective Elementary Teachers Toward Arithmetic," The Arithmetic Teacher, 9:418-424, December, 1962.

with a slight shift to the favorable side. Thirty-eight per cent of the students claimed they disliked arithmetic very much, twenty-four per cent liked arithmetic extremely well, and thirty-eight per cent liked arithmetic fairly well but not enthusiastically.

In a similar study, Smith[26] compared the attitudes toward arithmetic of students in his arithmetic method classes with those that Dutton tested in 1954. His subjects consisted of one hundred sixteen females and seven males. On a self-rating scale, eleven per cent declared themselves on the negative side, seventy-five per cent on the positive side, and the rest were neutral. Students with the most favorable attitudes marked statements indicating that arithmetic is interesting, challenging, and gives a feeling of accomplishment. The unfavorable attitudes resulted from a lack of understanding, poor teaching, and lack of teacher enthusiasm. A consideration of all the data indicates the present group has a more favorable attitude toward arithmetic than Dutton's group ten years ago.

Aiken and Dreger[27] correlated the attitude scores of three hundred ten college students with the remembered characteristics of their former teachers. The data shows a positive relationship exists between the two. However, they found no evidence that mathematics attitudes of students are related to the students' perception of their parents attitude toward the subject. In a later study, Aiken[28] found the attitudes toward mathematics

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[26]Frank Smith, Prospective Elementary Teachers' Attitude Toward Arithmetic," The Arithmetic Teacher, 11:474-477, November, 1964.

[27]Lewis R. Aiken and Ralph M. Dreger, "The Effects of Attitude on Performance in Mathematics," Journal of Educational Psychology, 52:19-24, February, 1961.

[28]Lewis R. Aiken, "Personality Correlates of Attitude Toward Mathematics," The Journal of Educational Research, 56:476-480, May, 1963.

of one hundred sixty female college sophomores were highly related to their statements about previous mathematics teachers.

Conclusions reached by Poffenberger and Norton[29] are the exact opposite to those obtained in the above two studies. They gave an attitude questionnaire to three hundred ninety college freshmen, almost equally divided between the two sexes. There was a slight tendency to dislike arithmetic since fifty-two per cent of the students reported liking school in general very much but only twenty-five per cent reported liking arithmetic and mathematics very much.

In relating the attitude scores of the students to various factors, they found that only the parents' attitudes as perceived by the students were significantly related. In other words, students with favorable attitudes toward mathematics reported their parents liked mathematics and expected them to achieve well in it. The reverse holds true for students with unfavorable attitudes. The attitude toward the teacher or influence of the teacher was only slightly related with student attitude scores. Many reported liking the teacher but not the subject. Perhaps a higher positive correlation would have resulted if attitude scores had been correlated with students' perception of teacher feeling toward mathematics. The British researcher, Biggs,[30] states, "The influence of the teacher is more likely to depend upon his own attitude to the subject he, and especially she, teaches, rather than upon the child's personal liking for

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[29] T. Poffenberger, and D. Norton, "Factors in the Formation of Attitudes Toward Mathematics," The Journal of Educational Research, 52: 171-176, 1959.

[30] J. B. Biggs, "Attitudes Toward Arithmetic-Number Anxiety," Educational Research, 1:6-20, June, 1959.

him or her."

The results from the above studies indicate that many students have ambivalent feelings toward mathematics and arithmetic. They like some areas and dislike others. The extremes, students with either very positive or very negative attitudes toward arithmetic, are exceptions to the rule. The attitudes of prospective elementary school teachers toward arithmetic have improved over the last decade. However, the extent of teacher and parental influence on attitude development toward arithmetic is not conclusively known.

PERSONALITY FACTORS

An unusually interesting study of the attitudes of young children toward mathematics has been reported by Plank.[31] The case study method was used with twenty children, some of whom were retarded while others were accelerated in arithmetic. Of special significance is the evidence of the relation of personality characteristics, such as insecurity, anxiety, and rigidity to performance in arithmetic situations. Among the conclusions occurs the following: "The insecure children show a definite discrepancy between their scores in reasoning and computation in their achievement tests. They can neither stand the competitive atmosphere that goes with computation nor the emphasis on speed while they are trying to be accurate." The resulting frustration caused them to fear and dislike mathematics and thus withdraw from all possible contact with the subject.

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[31]E. N. Plank, "Observations on Attitudes of Young Children Toward Mathematics," Mathematics Teacher, 43:252-263, August, 1950.

He claims aggressiveness is an essential personality trait for successful mathematical activity.

Biggs,[32] a British researcher, maintains that certain types of personalities are better suited to mathematical study than others. Character traits such as emotional instability and anxiety have been shown to have an adverse affect on mathematical achievement. He feels no subject arouses so much distaste in boys and girls as mathematics, with the girls suffering more from this distaste than the boys.

Carey[33] limited her study to attitudes toward problem-solving. She attempted to show that the difference in performance in problem-solving between the sexes was due to a difference in attitude toward problem-solving. Her instruments consisted of two equivalent forms of an attitude scale and two sets of problems. Ninety-six college subjects wrote form A of the attitude scale and one set of problems. This was followed by a group discussion on intellectual activity and factors involved in solving problems successfully. Following this discussion, the alternate form of the attitude scale and the other set of problems were administered.

Men received a significantly higher score on both the attitude scale and problems than did the women. Correlations computed between the attitude scale scores and problem-solving scores for both sexes separately indicates there is a positive relationship between attitude toward problem-

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[32]J. B. Biggs, "Attitudes To Arithmetic-Number Anxiety," Educational Research, 1:6-20, June, 1959.

[33]Gloria L. Carey, "Sex Difference in Problem-Solving Performance as a Function of Attitude Differences," Journal of Abnormal and Social Psychology, 56: 256-260, No. 2, 1958.

solving and achievement in it. Following the discussion, female subjects showed a marked improvement in performance, although they did not register an improved attitude on the questionnaire. It would seem that more than a few discussions are required to change attitudes that appear to be basic to the culturely defined role. The males registered no significant difference on either questionnaire. That the women made a greater relative improvement in their performance is not surprising, since initially they had a more unfavorable attitude and poorer performance. Thus, the possibility for improvement was greater. The major conclusion the author reached in her study is that poor problem-solving behavior on the part of the women is due to a negative attitude.

This approach was carried one step further by Milton[34] who attributed sex differences in problem-solving to sex-role identification. He felt the cause of poor achievement and unfavorable attitudes toward problem-solving by females was caused by their role identification. To test his hypothesis, he administered several instruments to 129 college students to determine the extent of their masculinity-femininity identification. The subjects were also asked to solve twenty problems on which sex differences had been previously found. In his conclusions he states:

> The results indicate there is a positive relationship between masculine sex-role identification and problem-solving skill both across sexes and within a sex. When allowance is made for this relationship, the difference between men and women in problem-solving performance is diminished....Men who identify with the masculine role are better problem solvers than those who identify with a more feminine role, and conversely, women who identify with the appropriate sex-role have poorer problem-solving scores than do women who have a more masculine identification.

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[34] G. A. Milton, "The Effects of Sex-Role Identification Upon The Problem-Solving Skill," Journal of Abnormal and Social Psychology, 55: 208-214, No. 2, 1957.

Perhaps, the difference in problem-solving skill is a part of the general difference between men and women. It is believed men have characteristically different behavior, attitudes, emotions, and motivations than do women. This would certainly warrant further investigation.

In doing a study on personality and attitude toward mathematics, Aiken[35] administered three personality trait tests, an aptitude test, and an attitude scale to one hundred sixty female college sophomores. In the analysis of data, mathematical ability was statistically controlled. His results suggest women with more favorable attitudes toward mathematics tend to be more outgoing, conscientious, self-controlled, intellectually mature, and place more value on theoretical matters than those with less favorable attitudes. This study would be of greater value if it had included women from more than one college.

The results from another study, with a similar approach, by Aiken and Dreger[36] suggests there is a positive relationship between leadership qualities of college freshmen males and their attitude toward mathematics. For females, those making the higher scores on personality variables which indicate a good adjustment to reality also tended to have more favorable attitudes toward mathematics.

These findings suggest attitude toward mathematics is related to a broad constellation of personality variables which indicate adjustment and interest. Further research is necessary before definite conclusions

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[35]Lewis R. Aiken, "Personality Correlates of Attitude Toward Mathematics," The Journal of Educational Research, 56:476-480, May, 1963.

[36]Lewis R. Aiken, and Ralph M. Dreger, "The Effect of Attitudes on Performance in Mathematics," Journal of Educational Psychology, 52:19-24, February, 1961.

can be reached about the role personality plays in attitude development toward mathematics. Since most of the studies mentioned in this section have been conducted upon a college population, there is little evidence as to how far these conclusions can be generalized.

ATTITUDE SCALE CONSTRUCTION

Although several procedures have been developed for constructing attitude scales, only the two most widely known techniques are discussed in this section. In addition, a review of a study dealing with the development of an attitude scale toward mathematics is presented.

Probably the most widely used attitude scale construction technique was developed by Likert.[37] Each item in a Likert-type scale consists of a statement with which the student indicates agreement or disagreement. Very often this is done on a three-point scale (agree, uncertain, disagree) or a five-point scale (strongly agree, agree, uncertain, disagree, strongly disagree). These responses are weighted from 3 to 1 or 5 to 1. The students are encouraged not to use the "uncertain" response very often.

Statements for a Likert-type scale are collected by means of free responses of students in interviews, or essays and statements written by the students expressing their feelings about the object. The preferred procedure is to develop more items than will be needed, and then eliminate those that do not contribute much to the overall purpose of the scale.

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[37]Allen L. Edwards, Techniques of Attitude Scale Construction, Appleton-Century-Crofts, Inc., 1954), pp. 149-159.

A subject's score would be the sum of the weights of the items in the instrument. Those items are the most discriminating which show the greatest discrepancy in mean response between high and low scoring groüps. "The final attitude scale is then constructed by choosing the twenty to twenty-five items from the total list which show the greatest discrimination."[38]

Prior to the development of the Likert-type scale, the method developed by Thurstone[39] was widely used. The purpose of the Thurstone or equal-appearing intervals method is to obtain an attitude measure in which equal differences in scores have the same meaning in all parts of the scale. For instance, the difference between a score of 2 and a score of 6 is assumed to mean the same difference in intensity of attitude as that between 5 and 9.

To build this scale, a large number of statements are collected which express some kind of opinion about the attitude under study. These statements must cover the entire continuum about the object, from extreme favorableness to extreme unfavorableness. These statements are placed on separate sheets of paper and distributed to 50 or more judges, who sort them into eleven piles according to their view of each statement as a favorable or unfavorable attitude toward the subject. The piles represent the attitude continuum from one extreme to the other in equal-appearing intervals. The score values or the number of the piles to which each

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[38]H. H. Remmers, Introduction to Opinion and Attitude Measurement (New York: Harper and Brother, 1954), p. 95.

[39]Edwards, op. cit. pp. 83-116.

statement is assigned by the various judges is recorded. Both the average score and the degree of consistency in the assigned scores are considered in selecting about 22 items for the final form of the scale. The student checks only those items with which he agrees. The scale value of each item does not appear on the scale, and the items are not placed in the continuum order. The average of the scale values of the statements checked is the student's attitude score.

One study was mainly concerned with constructing a valid and reliable attitude scale toward mathematics. Ellingson[40] collected three thousand statements from six hundred high school students dealing with student feelings about mathematics. From these he selected one hundred fifty representative items which were given to fifty judges to place on an eleven point scale. Thirty-six of the judges returned the requested information. He, then, selected the fifty best items and constructed two equivalent forms of a Thurstone-type attitude scale. The reliability between the alternate forms was .77.

The classroom teachers administered both forms of the attitude scale to seven hundred fifty-five high school students representing various types of mathematics classes. He obtained the following Pearson Product-Moment Correlations between:

(1) attitude scale score and teacher rating of students; r = .48

(2) attitude scale score and teacher grades; r = .39

(3) attitude scale score and mental ability; r = .30

(4) teacher rating and teacher grades; r = .87

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[40]James B. Ellingson, "Evaluation of Attitudes of High School Students Toward Mathematics," (Unpublished Doctoral Dissertation, University of Oregon, 1962.)

In summary, it must be recognized that in none of these procedures has the problem of validity been solved. The validity of the instrument is either appraised by a logical judgment that the information obtained is relevant to the attitude presumed to be measured or by the use of outside criteria which may present as much of a validity problem as the original instrument. However, a lack of perfect evaluation techniques does not imply we should avoid doing attitudinal studies.

MODERN VS. TRADITIONAL

Research studies comparing attitudes of modern and traditional mathematics students are few in number. The writer was able to locate only two studies which deal with this area. On the other hand, numerous articles appear giving the teacher's perception of her own reaction as well as those of her students toward the new courses. A few representative articles of the latter category are summarized. The two studies will be dealt with in greater detail.

Fisher[41] described two workshops which were held to prepare teachers to teach modern mathematics materials to their fourth grade classes for a four to six week period. During the teaching interval, the teachers prepared lessons co-operatively. On commenting on the final workshop held for evaluation purposes, she states: "The most rewarding outcome of this was the obvious enthusiasm on the part of teachers and and pupils involved."

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[41] Loretta B. Fisher, "How Curriculum Builders View "New Math" Ideas," School Science and Mathematics, 64:31-36, January, 1964.

Fehr[42] in discussing the School Mathematics Study Group and the University of Illinois Committee on School Mathematics programs, says, "most teachers who have used the materials are enthusiastic and say they will never return to the old. Students enjoy the work and show far more understanding." In her appraisal of two modern seventh grade courses, Willerding[43] expresses a similar sentiment by stating, "The reports of teachers are almost unanimous that the interest of students in the "new" mathematics is greater than in the traditional program." She found the teachers equally enthusiastic about the new materials. From the enthusiasm generated and the achievement level of the students using the new materials, she concludes that new programs will produce fewer arithmetic haters and more good thinkers.

The above writers speak highly of the new programs. However, their conclusions are based solely on general observations rather than on concrete evidence. The increased enthusiasm on the part of both teachers and students could be partly caused by the Hawthorne and Halo effect. The possibility of this being so must be considered in any conclusions reached.

A rather intensive study on psychological factors in mathematics education was carried out by Alpert, Stellwagon, and Becker.[44] The student sample consisted of two hundred seventy subjects, half boys and half girls, all in grade seven. Half of the subjects were in School

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[42] Howard F. Fehr, "A Great Step Forward," Education Digest, 28:42-45, January, 1963.

[43] Margaret F. Willerding, "A Critical Look at the New Mathematics for Seventh Grade," School Science and Mathematics, 62:215-220, March, 1962.

[44] R. Alpert, G. Stellwagon, and D. Becker, "Psychological Factors in Mathematics Education," School Mathematics Study Group Newsletter No. 15:17-24, April, 1963.

Mathematics Study Groups (SMSG) classes, and the other half were in conventional mathematics classes. Parents and teachers were also included in the study.

They found a powerful interaction between program and teacher. In other words, a highly theoretical orientation on the part of the teacher who teaches both SMSG and conventional classes, leads to high positive feelings in SMSG classes but not in conventional ones. Thus, it appears that a theoretical teacher's effect on positive mathematics feeling is greatly facilitated when he is teaching a theoretical mathematics program. This implies that best results can be obtained when a certain type of mathematics teacher is combined with a certain type of mathematics program.

The overall results indicate the experimental program does not increase students' positive feelings toward mathematics, either absolutely or relative to the traditional mathematics program. In connection with this, they state:

> In regard to student attitudes toward mathematics, the results are central in evaluating the effects of the SMSG program. In the Fall, at the start of the school year, the SMSG students are found to be more favorably oriented toward mathematics than the non-SMSG students. However, the data shows that, at the end of the school year, the SMSG program has not been able to maintain its momentum. While non-SMSG mathematics attitudes remained relatively constant, SMSG students attitudes fell. The general enthusiasm was gone. These results, while failing to show the hoped-for beneficial attitudinal effects of the experimental program, do show that it is indeed possible to arouse seventh graders' excitement about mathematics. This in itself is encouraging; the job now is to modify further the material and to train teachers in a way that will justify the students' initially high expectations.[45]

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[45] *Ibid.*, pp. 23-24.

Rosenbloom[46] suggests that the true payoff in achievement in SMSG courses in grades seven and eight may not be observable until the tenth grade. The same might be true for attitudes. Perhaps, if the students in the above study were re-tested in grade ten, there might be a rejuvenation of their attitudes toward the SMSG program.

Phelps conducted a study involving attitude comparison between modern and traditional mathematics courses at the grade five and eight levels.[47] At each grade level six classes of SMSG and six classes of conventional mathematics students were involved in the study. At both grade levels, the modern mathematics students were in their second year of studying SMSG materials.

His results indicate no significant difference in attitude between the two groups at the grade eight level. However, the grade five SMSG students did have a better attitude toward mathematics than their counterparts in the traditional classes. An extremely interesting result is that SMSG girls, overall, indicated more positive attitudes than did the boys in the traditional classes. From this, he concluded that the SMSG materials do foster a more positive attitude among the girls in both grades. However, this is not significant at either the .01 or .05 level. Another startling result is that at the grade five level the girls scored significantly higher than the boys on the attitude scale. At the grade eight level there was no significant difference.

A possible reason for the better attitudes expressed by SMSG

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[46]Paul Rosenbloom, "Minnesota National Laboratory Evaluation of SMSG, Grades 7-12," Newsletter No. 10, November, 1961:12-26,(Stanford, California: Leland Stanford University, 1961.)

[47]Jack Phelps, "A Study Comparing Attitudes Toward Mathematics of SMSG and Traditional Elementary School Students," (Unpublished Doctoral Dissertation, Oklahoma State University, August, 1963.)

students at the grade five level is that their average class size was approximately eighteen students while the traditional classes had about thirty students per class. This discrepancy in class size would greatly increase the influence of the teacher variable. In the smaller classes, the teacher would presumably be able to give more individual attention. This could result in a more favorable attitude toward mathematics as indicated by research reviewed earlier.

There appears to be a contradiction between conclusions reached from teacher-student perception of new materials and results accruing from statistical studies. This paradoxical situation warrants further investigation.

SUMMARY

The attitudinal studies discussed indicate that student attitudes, for and against arithmetic, appear as early as grade three. The majority of the students like arithmetic and mathematics. There is no conclusive evidence to support the commonly held belief that boys like arithmetic better than girls. Several researchers reported the girls have a more favorable attitude to the subject than boys. Most of the studies agreed there is a positive relationship between performance and attitudes in regard to mathematics.

Teachers and parents were found to have some influence in the development of student attitudes, with the teacher having a greater impact. However, the exact nature and extent of this relationship is not known.

Personality factors indicating aggressiveness were reported

to be positively related to favorable attitudes toward problem-solving. Other studies presented evidence to support the supposition that masculine sex-role identification and favorable problem-solving attitudes are positively correlated.

Contrary to expectation, the two statistical studies on attitude comparison between modern and conventional mathematics students, indicates no significant difference between the two groups.

CHAPTER IV

EXPERIMENTAL DESIGN AND STATISTICAL PROCEDURES

The purpose of this study, as stated in Chapter I, is to compare the attitudes of traditional and modern mathematics students. The relationship between student attitudes toward mathematics and sex, between student attitudes and scholastic ability, and between student attitudes and achievement in problem-solving is also being investigated.

The present chapter explains the experimental design used, the construction of the attitude scale and the methods used to establish the validity and reliability of the scale and the statistical procedures used to analyze the data.

HYPOTHESES TO BE TESTED

The hypotheses to be tested by various statistical procedures are:

I. Modern mathematics students possess a significantly more favorable attitude toward mathematics than traditional mathematics students.

II. Modern mathematics students have a significantly more favorable attitude toward mathematics than traditional mathematics students at the three scholastic ability levels.

III. The highest scholastic ability group possesses a significantly more favorable attitude toward mathematics than the lowest scholastic ability group.

IV. Boys have a significantly more favorable attitude toward mathematics than girls.

V. Boys and girls studying modern mathematics respectively possess a significantly more favorable attitude toward mathematics than their counterparts studying traditional mathematics.

VI. There is a significant positive correlation between attitude toward mathematics and scholastic ability.

VII. There is a significant positive correlation between attitude toward mathematics and problem-solving skill.

DESIGN OF THE ATTITUDE SCALE

In order to determine the attitudes of the students toward mathematics, the writer undertook to develop an attitude scale. After considering some of the various possible methods of constructing attitude inventories, a multiple choice type of scale was decided upon. The stem of each item has five possible completion responses. The student marks one of these responses to complete the stem. These choices are weighted from five to one with the response indicating the most favorable attitude, as judged by the writer, being weighted as five and the least favorable as one. The total score on the attitude scale represents the sum of the weights as indicated by the marked responses to the items. The highest possible score is 125 and the lowest is 25. An attitude scale of this nature not only retains the practical administrative advantages of a Thurstone and Likert[1] type scale, but also defines the items more clearly,

[1]Mary Corcoran and E. Glenadine Gibb, "Appraising Attitudes in the Learning of Mathematics," The National Council of Teachers of Mathematics, Twenty-sixth Yearbook, 1961, pp. 105-122.

making it easier for the students to understand their meaning.

In constructing the attitude scale, the investigator searched the literature to determine what are considered positive and negative attitudes toward mathematics. Many of the ideas gained were incorporated into the instrument. In addition, helpful suggestions were sought and received from professional mathematics educators, educational psychologists, and a member of the Mathematics Department of the University of Alberta. Special attention was paid to the terminology used, so the instrument would not be biased towards either the experimental or control group.

The first draft of the instrument, which consisted of thirty multiple choice items, was administered by the writer to a grade nine class of twenty-four students in Saskatchewan who were taking modern mathematics, and to a grade nine class of twenty-four students in Alberta who were taking traditional mathematics. These two classes were not part of the main experimental group. Their teachers were asked to place their students into five categories of approximately equal numbers according to their perception of the student's attitude. These groups were weighted from five to one with the group with the most favorable attitude toward mathematics weighted as five and the group with the least favorable attitude as one. To facilitate the teacher ratings and to make them more objective, a guide[2] was prepared and explained to aid the teachers in their ratings. The teachers made their evaluations by using the checklist and drawing on the knowledge of the students they gained through approximately eight months' association with them in their mathematics classes. The

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[2]See Appendix A

teachers were also asked for a list of the Easter mathematics marks of the students.

The writer endeavored to establish some rapport with the students in order to create an atmosphere in which the students would feel free to express their true feelings about the items. The students were told that their responses would be kept confidential and the results would not affect their school grades in any way. The teachers were not present in the classroom during the writing of the attitude scale. After the students had completed the instrument, several minutes were spent discussing the various items. On the basis of this discussion, two of the items had to be discarded since the students did not understand their full meaning.

The response sheets were scored and divided into approximately two equal parts on the basis of total score received on the attitude scale. The higher scoring group contained twenty-three scores and the lower group twenty-five. A point biserial correlation as described by Ferguson[3] was then used to get an index for the discriminating power of each item between high and low scorers on the attitude scale. The larger the numerical value of the correlation index, the greater is the power of the item to discriminate between students who have a favorable attitude and those who have an unfavorable attitude toward mathematics. Three of the items which had an extremely low point biserial correlation were deleted from the instrument, since they were not contributing to its overall purpose. The point biserial correlation coefficients on the

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[3]George A. Ferguson, "Statistical Analysis in Psychology and Education," (Toronto: McGraw-Hill Book Company, Inc., 1959), pp. 199-202.

attitude scale range from .23 to .59. The final form of the attitude scale[4] is presented in Table II. The point biserial correlation coefficient of each item is given along with the category and sub-category into which each item falls in the taxonomy internalization continuum.

Individual items on the attitude scale toward mathematics do not consider all of the categories and sub-categories of the internalization continuum through which attitude extends. The highest scores on the attitude scale can, at best, be taken as evidence of commitment to a value. However, this is not a shortcoming of the instrument since the purpose of the attitude scale was to determine the attitude of groups of individuals toward mathematics rather than determine the intensity of the attitude of a particular individual.

Corcoran and Gibb[5] point out that the problem of validity has not been solved by the various methods of constructing attitude scales. They state, "Some attempts have been made to validate attitude measures in terms of the extent to which verbal responses are related to outside criterion measures of attitudes. ... However,the criterion in such cases may present as much of a validity problem as the original instrument." Although this method of validation has shortcomings, it is one of the better methods available, and consequently, it was used by the writer.

Two measures of outside criteria were used. Teacher ratings of

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[4]See Appendix B for pilot version of attitude scale.

[5]Mary Corcoran, and E. Glenadine Gibb, "Appraising Attitudes in the Learning of Mathematics," The National Council of Teachers of Mathematics, Twenty-sixth Yearbook, 1961, p. 120.

student attitudes toward mathematics was used as one, since the mathematics teacher is in an excellent position to observe student activity during his classes. The correlation between teacher ratings and attitude scale scores yielded a concurrent validity coefficient of .43. The other criteria, students' Easter mathematics marks, was included because the related literature shows a positive relationship between student attitudes and achievement in mathematics. A construct validity coefficient of .37 was obtained from the correlation of these two variables. A degree of content validity for the attitude scale was obtained by submitting the items to several mathematics educators for constructive criticism. Teacher ratings and students' mathematics marks correlated highly with a coefficient of .83.

Approximately two months after the first administration of the attitude scale, it was re-administered to the Saskatchewan grade nine classes to obtain a test-retest reliability coefficient. Ebel[6] says that the size of a test-retest reliability coefficient indicates not only the precision of measurement of the test, but also the stability of the trait being measured. A test-retest reliability coefficient of .77 was obtained for the attitude scale.

An internal consistency coefficient was also calculated for the attitude scale. An instrument possesses high internal consistency if it is composed of items which measure the same thing and which are therefore highly intercorrelated. The Ebel[7] method, based on analysis of

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[6]Robert L. Ebel, Measuring Educational Achievement, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965), p. 467.

[7]*Ibid.*, p. 329.

TABLE II

FINAL VERSION OF ATTITUDE SCALE

A MATHEMATICS STUDY

The best answer to each statement is your own first impression. There are no right or wrong answers. Think carefully, but do not spend too much time on any one question. Let your own personal experience guide you to choose the answer you feel about each statement.

R_{pbi} I_{tc} Please mark a response for every statement.

.36 2.3 1. I find most mathematics lessons:
a) extremely interesting.
b) quite interesting.
c) interesting
d) not very interesting.
e) not interesting at all.

.38 3.1 2. A knowledge of mathematics for any job at all is:

a) most important.
b) very important.
c) quite important.
d) of small importance.
e) not important.

.55 2.3 3. If I did not have to take mathematics, I would like school:

a) much less.
b) a little less.
c) same as now.
d) a little better.
e) much better.

.31 3.1 4. Mathematics is:

a) the most important subject.
b) one of the more important subjects.
c) just as important as any other subject.
d) not as important as some of the other subjects.
e) the least important subject.

.51 2.3 5. I find problem solving:

a) extremely interesting.
b) quite interesting.
c) interesting.
d) not very interesting.
e) not interesting at all.

TABLE II

.26 2.3 6. When I have difficulty with a new topic in my mathematics course, I ask my teacher to clarify the section:

a) very frequently.
b) frequently.
c) sometimes.
d) hardly ever.
e) never.

.44 3.2 7. If books about mathematics were available, I would:

a) read most of them.
b) read some of them.
c) look at the diagrams and pictures.
d) page through some of them.
e) never look at them.

.45 3.1 8. If someone says mathematics classes are worthless and a waste of time, I would:

a) strongly disagree.
b) tend to disagree.
c) not take a side.
d) tend to agree.
e) strongly agree.

.53 2.2 9. When I do my homework, my mathematics is:

a) always done first.
b) often done first.
c) usually done first.
d) sometimes done first.
e) never done first.

.58 2.3 10. I find mathematical puzzles:

a) extremely interesting.
b) quite interesting.
c) sometimes interesting.
d) not very interesting.
e) not interesting at all.

.59 3.2 11. I would be interested in taking other subjects that make use of:

a) a great deal of mathematics.
b) quite a bit of mathematics.
c) some mathematics.
d) a little mathematics.
e) no mathematics.

TABLE II

.29 2.3 13. If given the opportunity to join one of the following clubs, I would prefer a:

a) mathematics club.
b) science club (physics).
c) science club (chemistry).
d) science club (geology).
e) literary club.

.35 2.3 14. If I could receive one of the following magazines for a year, I would pick:

a) a mathematics magazine for high school students.
b) a magazine combining science and mathematics for high school students.
c) a science magazine for high school students.
d) a geology magazine for high school students.
e) a literary magazine for high school students.

.36 2.2 15. When I study my mathematics course, I most often:

a) make written summaries of the sections covered.
b) do additional problem solving.
c) do many drill questions.
d) memorize the formulas given in the text.
e) look over some work done previously.

.43 3.1 16. If I listed my courses in order of preference, I would place mathematics:

a) first.
b) second.
c) third.
d) fourth.
e) fifth.

.39 2.3 17. Whenever mathematical problems are presented to us for solving, I get:

a) a great deal of satisfaction in working them out.
b) quite a bit of satisfaction in working them out.
c) some satisfaction in working them out.
d) very little satisfaction in working them out.
e) no satisfaction in working them out.

.28 2.3 18. My mathematics course has made:

a) mathematics enjoyable for me.
b) mathematics a pleasant course.

TABLE II

c) me feel indifferent towards mathematics.
d) mathematics classes an uncomfortable experience for me.
e) me strongly dislike mathematics.

.24 2.2 19. I feel my mathematics teacher:

a) enjoys teaching mathematics.
b) gets some pleasure in teaching mathematics.
c) gets some satisfaction in teaching mathematics.
d) neither likes or dislikes teaching mathematics.
e) dislikes teaching mathematics.

.51 2.3 20. When I do my mathematics homework, I am usually:

a) extremely interested.
b) interested.
c) somewhat interested.
d) not too interested.
e) not interested at all.

.45 2.3 21. When we start a new topic in mathematics, I am usually:

a) keenly interested.
b) interested.
c) somewhat interested.
d) not too interested.
e) not interested at all.

.31 2.2 22. The average amount of time I spend on homework assignment in mathematics takes the following time per day:

a) more than one hour.
b) 3/4 hour to one hour.
c) 1/2 hour to 3/4 hour.
d) 1/4 hour to 1/2 hour.
e) 0 hours to 1/4 hour.

.26 2.2 23. When I get an assignment in mathematics:

a) I do it immediately.
b) I do it eventually.
c) I may get it done.
d) I put it off as long as possible.
e) I don't do it.

.36 3.1 24. Most of my work in this class is done:

a) to satisfy my curiosity about mathematics.
b) to gain competence in mathematics.
c) to get a good mark.

d) to just pass the class.
e) to put in the time alloted to mathematics.

.23 2.2 25. During mathematics lessons, I feel:

a) extremely confident in myself.
b) quite confident in myself.
c) confident in myself.
d) a little unsure of myself.
e) very unsure of myself.

R_{pbi} represents the point biserial correlation coefficients of the items.

I_{tc} denotes the categories and sub-categories in the taxonomy internalization continuum.

variance, was used in determining the internal consistency of the scale. By using this method, a coefficient of .86 was obtained for the attitude scale.

COLLECTION OF DATA

The teachers and students participating in this experiment were selected by members of the Alberta Junior High School Mathematics Sub-committee. One of the main determining factors in the selection of students was finding teachers willing to participate in the experimental program. This program started in the 1962-63 school term with considerable revisions made in the following school year. During the 1964-65 school term[8], eighteen classes of grade nine students from the two major cities and four towns in the Province of Alberta were involved in the study. Thirteen of the classes were taking an organized modern mathematics course. The remaining five classes of students were enrolled in a conventional mathematics course. Of the fourteen teachers participating in the study, nine were teaching modern mathematics courses and the other five traditional classes.

The fact that the sample used was not a random sample of the Alberta student population must be remembered when considering the conclusions obtained. However, a reference to Table III on page 62 shows that a wide range of student scholastic ability was represented.

As stated in Chapter I[9], the students studying the different

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[8]See Chapter I, p. 3 for detailed information about the classes.

[9]See Chapter I, p. 4.

mathematics programs were comparable in overall scholastic ability at the start of this experimental program. Also, information obtained about the teachers' training and experience would indicate there is little difference in this respect between the two major groups of teachers involved in this study.[10]

From 4A[11] of The Cooperative School and College Ability Test (SCAT) was administered to all students participating in the experiment in September, 1963. This was before the idea for the present study was conceived. This test consists of four parts, two of which deal with verbal ability and two with quantitative ability. Although a verbal and a quantitative score was obtained, only the total raw score entered into the analysis of the data in this study. The SCAT test is reported as having a Kucher-Richardson (Formula 20) estimated total reliability score of .95.[12] The same source described the test as being an efficient measure of future scholastic success. It measures school-learned or specifically developed abilities rather than abstract, hard-to-explain psychological traits.

Under the directorship of the Alberta Junior High School Mathematics Sub-committee, the grade nine problem-solving subtest of the

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[10] D. B. Harrison, "An Analysis of the Effectiveness of Three Mathematics Programs at the Grade Eight Level," (Unpublished Master's Thesis, University of Alberta, Edmonton, 1964), p. 59.

[11] Educational Testing Service, _Cooperative School and College Ability Tests, School Ability Test_, Form 4A. (Princeton: Cooperative Test Division, Educational Testing Service, 1956.)

[12] Frederick B. Davis, Oscar Krison Buros (editor,) _The Mental Measurements Yearbook_ (Highland Park, N.J.: The Gryphon Press, 1959), pp. 451-453.

Iowa Tests of Basic Skills (IOWA)[13] was administered to the students involved in the experiment in April, 1965. Herrick[14] reports the IOWA test as having a split-half reliability coefficient of .98 and sub-test reliability coefficients in the .80's. This test was designed to measure generalized educational skills over a wide range of ability rather than mastery of specific facts or topics. The problem situations in the problem-solving subtest are reported by the reviewers as being heavily loaded in the direction of situations which involve money.

In April 1965, the teachers were asked to complete a questionnaire prepared by the Alberta Junior High School Mathematics Sub-committee. Teacher comments are presented in Appendix C to those questions which were pertinent to this study. Also, a brief summary of teacher reactions to the new mathematics materials appears in Chapter VI.

The investigator administered the attitude scale personally to avoid feelings of intimidation on the part of the students in May, 1965, to all classes involved in the study. He found the teachers most co-operative and most of them expressed keen interest in the study. He endeavored to create an atmosphere which was conducive to free expression of feelings by the students. The pupils were told their responses would be kept confidential, and that the results would in no way affect their school grades. It was necessary for the students to write their name, sex, course, and school on the response sheets since the SCAT and IOWA

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[13]E. F. Lindquist and A. N. Hieronymus, Iowa Tests of Basic Skills for Grades 3 - 9 (Boston: Houghton Mifflin Company, 1955).

[14]Virgil E. Herrick; Oscar Krisen Buros (editor), The Fifth Mental Measurements Yearbook (Highland Park, N.J.: The Gryphon Press, 1959), pp. 33-36.

problem-solving tests were not administered at this time. In all cases but one, the teacher left the classroom after introducing the writer to the students.

After all the data was collected, the writer scored the attitude scale by summing the weighted responses. The results from three of the response sheets had to be omitted in the analysis of the data, since all of the items were not completed. Support for using the total score in the analysis of the data is given by Green[15] when he states that,

> . . .Like many psychological variables, attitude is a hypothetical or latent variable, rather than an immediate observable behavior. The concept of attitude does not refer to any one specific act or response of an individual, but is an abstraction from a large number of related acts or responses.

EXPERIMENTAL PROCEDURES

Students who had written all of the tests administered in the course of the experiment were assigned an identification number. The student's I.D. number, attitude scale responses, attitude scale total score, verbal and quantitative SCAT scores as well as SCAT total score, and grade nine problem-solving score of the IOWA test were punched on an IBM card. In addition, the student's sex and type of mathematics course (modern or traditional) were indicated on the IBM cards by code numbers. The 451 IBM cards resulting from the above procedures were then processed as briefly described in the following paragraphs.

Since the possibility exists that scholastic ability may have an effect on attitudes developed, the total sample was divided into

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[15]Bert F. Green, "Attitude Measurement," Handbook of Social Psychology, Vol. I (Addison Wesley Publishing Company, Inc.) p. 335.

approximately three equal groups on the basis of scholastic ability. A student with a SCAT total score of 96 or above was classified as scoring in the upper third of the scholastic ability range. Students with SCAT total scores from 85 to 95 inclusive scored in the middle third of the scholastic ability range, and those students whose SCAT total scores were 84 or less scored in the lower third. Table III on page 62 shows the distribution of subjects according to scholastic ability.

Hypothesis 1 was tested by an one-way analysis of variance. Ferguson[16] described the analysis of variance as a technique for dividing the variations observed into different parts, each part assignable to a known source, cause, or factor. In its simplest form the analysis of variance is used to test the significance of the differences between the means of a number of different samples. When only two means are present, this approach leads to the same result as that obtained from a t-test for the significance of the differences between means for independent samples.

Two major assumptions underlie the mathematical development of the analysis of variance. One of these is that the distributions of the variables in the populations from which the samples are drawn are normal. According to Johnson and Jackson, this assumption is assumed to be true if the sample used is large, since "the distribution is amazingly unaffected by lack of symmetry."[17] A further assumption is that the

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[16]George A. Ferguson, Statistical Analysis in Psychology and Education (Toronto: McGraw-Hill Book Company, Inc., 1959), pp. 227-241.

[17]Palmer O. Johnson, and Robert W. B. Jackson, Modern Statistical Methods: Descriptive and Inductive (Chicago: Rand McNally & Company, 1959) pp. 193-194.

TABLE III

CELL FREQUENCIES FOR INSTRUCTIONAL GROUP, SEX AND SCHOLASTIC ABILITY LEVEL CLASSIFICATIONS

SCAT ABILITY LEVELS	MODERN			TRADITIONAL			TOTALS		
	GIRLS	BOYS	TOTALS	GIRLS	BOYS	TOTALS	GIRLS	BOYS	GRAND TOTALS
96 - 109	51	66	117	18	23	41	69	89	158
85 - 95	57	47	104	20	22	42	77	69	146
32 - 84	56	54	110	22	15	37	78	69	147
TOTALS	164	167	331	69	60	120	224	227	451

variances in the populations from which the samples are drawn are equal. This is known as homogeneity of variance. Ferguson,[18] in commenting on these assumptions, states:

> With most sets of real data the assumptions underlying the analysis of variance are, at best, only roughly satisfied. The raw data of experiments frequently do not exhibit the characteristics which the mathematical models require. One advantage of the analysis of variance is that reasonable departures from the assumptions of normality and homogeneity may occur without seriously affecting the validity of the inferences drawn from the data.

The acceptability of the assumption of homogeneity of variance was verified by the use of Bartlett's test as described by Winer.[19]

Winer,[20] in stating the general purpose of factorial experiments, says,

> Factorial experiments permit the experimenter to evaluate the combined effect of two or more experimental variables when used simultaneously. Information obtained from factorial experiments is more complete than that obtained from a series of single-factor experiments, in the sense that factorial experiments permit the evaluation of interaction effects. An interaction effect is an effect attributable to the combination of variables above and beyond that which can be predicted from the variables considered singly. . . .
>
> At the end of a factorial experiment, the experimenter has information which permits him to make decisions which have a broad range of applicability. In addition to information about how the experimental variables operate in relative isolation, the experimenter can predict what will happen when two or more variables are used in combination. Apart from the information about interaction, the estimates of the effects of the individual variables is, in a sense, a more practically useful one; these estimates are obtained by averaging over a relatively broad range of other relevant experimental variables.

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[18] Ferguson, op. cit., p. 240.

[19] B. J. Winer, Statistical Principles in Experimental Design, (New York: McGraw-Hill Book Company, Inc., 1963), p. 95.

[20] Ibid., p. 140.

Winer[21] states that data involving unequal cell frequencies may appropriately be analyzed by the method of unweighted means. Therefore, it was decided to test hypotheses 2, 3, 4 and 5 by a two-way analysis of variance-unweighted means, since they have unequal cell frequencies and two experimental variables are used simultaneously. The statistics for this procedure is described in Winer.[22]

Tests of the significance of differences between pairs of means were carried out as explained by Winer.[23] This t-test takes into account the different cell frequencies. The test statistic is given by

$$t = \frac{\bar{A}_1 - \bar{A}_2}{\sqrt{MS_{w} \text{ cell} \left[L\ 1/n_1 + \frac{1}{n^2} \right]}} \quad , \text{ df} = N\text{-}pq, \text{ where}$$

A_1 is one of the cell means being compared.

A_2 is the other cell mean being compared.

$MS_{w.cell}$ is the pooled within cell variance.

n_1 is the cell frequency involved in the A_1 cell mean.

n_2 is the cell frequency involved in the A_2 cell mean.

p is the number of rows.

q is the number of columns.

df is the number of degrees of freedom.

Hypotheses 6 and 7 were tested using a Pearson product-moment

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[21] Ibid., pp. 241-244.

[22] Ibid.

[23] Ibid., p. 244.

correlation as explained by Ferguson.[24]

For all statistical tests on the differences between means carried out, the critical values used were the .05-level. The .05 and .01 probability levels are descriptive of the degree of confidence that a real difference exists, or that the observed difference is not due to the caprice of sampling. When the difference is said to be significant at the .05, or 5 per cent, level or less, the chances are 5 in 100 or less that the difference could result when the treatment applied was having no effect. A similar interpretation applies to a difference significant at the .01 level.

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[24]George A. Ferguson, Statistical Analysis in Psychology and Education (Toronto: McGraw-Hill Book Company, Inc., 1959), pp. 86-98.

CHAPTER V

THE FINDINGS OF THE STUDY

INTRODUCTION

In this chapter the data concerning the attitudes of the students toward mathematics is presented as determined from the results of the instruments employed. Also, tests of the hypotheses are made and the data presented. Each hypothesis is stated immediately before the presentation of the results and a concluding statement follows.

FREQUENCY DISTRIBUTION

In order to give some idea of the frequency distribution of student scores on the attitude scale, it was decided to arbitrarily create attitude score intervals. The range of 68 between the highest score (116) received and the lowest (48) was divided into five attitude score intervals. Table IV shows the frequency distribution and percentages of attitude scale scores at the five intervals according to sex and type of mathematics program.

FINDINGS FROM THE STATISTICAL ANALYSIS

Hypothesis 1

> Modern mathematics students possess a significantly more favorable attitude toward mathematics than traditional mathematics students.

Table V, page 68 lists the attitude scale mean scores and the variances of the two groups. Table VI, page 68 summarizes the analysis of variance carried out on the attitude scale scores. The abbreviation

TABLE IV

FREQUENCY DISTRIBUTION AND PERCENTAGES CLASSIFIED
BY SEX AND MATHEMATICS PROGRAM

Attitude Score Intervals	Modern						Traditional					
	Girls		Boys		Total		Girls		Boys		Total	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
102-116	8	2.4	20	6.1	28	8.4	5	4.2	9	7.5	14	11.7
87-101	62	18.7	54	16.3	116	35.1	16	13.3	21	17.5	36	30.8
78-86	38	11.5	46	13.9	84	25.4	15	12.5	17	14.2	32	26.7
63-77	41	12.4	38	11.5	79	23.9	20	16.7	10	8.3	30	25.0
48-62	15	4.5	9	2.7	24	7.2	4	3.3	3	2.5	7	5.8
Totals	164		167		331		60		60		120	

TABLE V

ATTITUDE SCALE SCORE MEANS AND VARIANCES
FOR INSTRUCTIONAL GROUPS

Group	Number	Mean	Variances
Modern	331	83.70	177.56
Traditional	120	84.32	195.46
Grand Mean		83.87	

TABLE VI

SUMMARY OF ANALYSIS OF VARIANCE OF ATTITUDE SCALE SCORES
FOR INSTRUCTIONAL GROUPS

Source	SS	MS	DF	F	
Groups	33.41	33.41	1	0.18	$p < 0.67$
Error	81853.37	182.30	450	--	--

$F_{.05}\ (1,450) = 3.84$

SS represents the "sums of squares" or "the sum of the squares of the differences between each score and its particular group mean." MS denotes a "mean square" or "variance estimate" or the "average variation per degree of freedom." F represents the F-ratio obtained by dividing MS_G by MS_E. P gives the level of probability at which the F-ratio is significant.

Since the observed F-ratio (0.18) for the comparison of attitude scale mean scores between modern and traditional mathematics students is not significant, Hypothesis 1 is rejected.

Hypotheses two and three are treated together since they are tested by the same analysis of variance.

Hypothesis 2

> The modern mathematics students possess a significantly more favorable attitude toward mathematics than the traditional mathematics students at each of the three scholastic ability levels.

Hypothesis 3

> The highest scholastic ability group possesses a significantly more favorable attitude toward mathematics than the lowest scholastic ability group.

Table VII on page 71 presents the attitude scale mean scores for the modern and traditional mathematics students at the three scholastic ability levels. Table VIII on page 71 gives a summary of the analysis of variance-unweighted means solution for the attitude scale scores at the three scholastic ability levels.

The observed F-ratio (0.41) for the interaction between program and ability level does not exceed the critical value of 3.84. Therefore, Hypothesis 2 is rejected.

The observed F-ratio (5.35) for the comparison of attitudes of the three scholastic ability levels exceeds the critical value (4.61)

for significance at the .01-level. Since the F-ratio is significant, tests of significance of the differences between pairs of means were carried out and the findings are presented.

A t-statistic is used to make comparisons between the means of the three scholastic ability levels within the modern and traditional mathematics programs. This procedure is described on page 64 of this study.

The results of this test on the cell means of the modern and traditional mathematics programs are as follows:

Modern Mathematics

$t_{\text{High vs Average}} = 2.08$

$t_{\text{High vs Low}} = 3.52$

$t_{\text{Average vs Low}} = 1.32$

$t_{.01}\ (445) = 2.33$

$t_{.05}\ (445) = 1.65$

Traditional Mathematics

$t_{\text{High vs Average}} = .21$

$t_{\text{High vs Low}} = 1.71$

$t_{\text{Average vs Low}} = 1.50$

$t_{.01}\ (445) = 2.33$

$t_{.05}\ (445) = 1.65$

In interpreting the above data, we must compare the values of t. If the value of t for the comparison of two cell means exceeds the value of t for .05 level of significance at the given degrees of freedom, then the difference between the two means is statistically significant.

The information obtained from the preceding tests indicates that modern and traditional mathematics students who are in the high

TABLE VII

ATTITUDE SCALE CELL MEAN SCORES AT THE THREE SCHOLASTIC ABILITY LEVELS

	Number	Modern	Number	Traditional
High	117	86.91	41	86.12
Average	104	83.19	42	86.50
Low	110	80.76	37	80.97

TABLE VIII

SUMMARY OF ANALYSIS OF VARIANCE -- UNWEIGHTED MEANS FOR ATTITUDE SCALE SCORES

Source	SS	DF	MS	F	
Program	29.05	1	29.05	0.16	$p < 0.69$
Ability	1,902.24	2	951.12	5.35	$p < 0.01$
Interaction	146.51	2	73.26	0.41	$p < 0.59$
Within	79,063.04	445	177.67		

$F_{.05}\ (1,445) = 3.84$ $\qquad$ $F_{.01}\ (2,445) = 4.61$

scholastic ability level have a significantly better attitude toward mathematics than their counterparts in the low scholastic ability level. Thus, Hypothesis 3 is accepted.

Figure 1 gives the relationship of the attitude scale mean scores for the modern and traditional mathematics groups. In this graphic illustration, the cell mean scores are plotted against the three scholastic ability levels for each group.

Since Hypotheses four and five are tested by the same analyses of variance, they are discussed together in this section.

Hypothesis 4

> Boys possess a significantly more favorable attitude toward mathematics than girls.

Hypothesis 5

> Boys and girls taking modern mathematics respectively possess a significantly more favorable attitude toward mathematics than their counterparts taking traditional mathematics.

Table IX on page 74 presents the attitude scale cell mean scores for boys and girls in the modern and traditional mathematics programs. Table X on page 74 gives a summary of the analysis of variance-unweighted means solution for the attitude scale scores of the boys and girls.

The observed F-ratio (5.89) for the comparison of the boys' and girls' attitudes toward mathematics in the two mathematics programs exceeds the critical value of 3.84 for significance at the .05 level. Since the F-ratio is significant tests of significance of the differences between pairs of means were carried out and the results are presented.

Since the observed F-ratio (1.18) for the interaction between program and sex is insignificant, Hypothesis 5 is rejected.

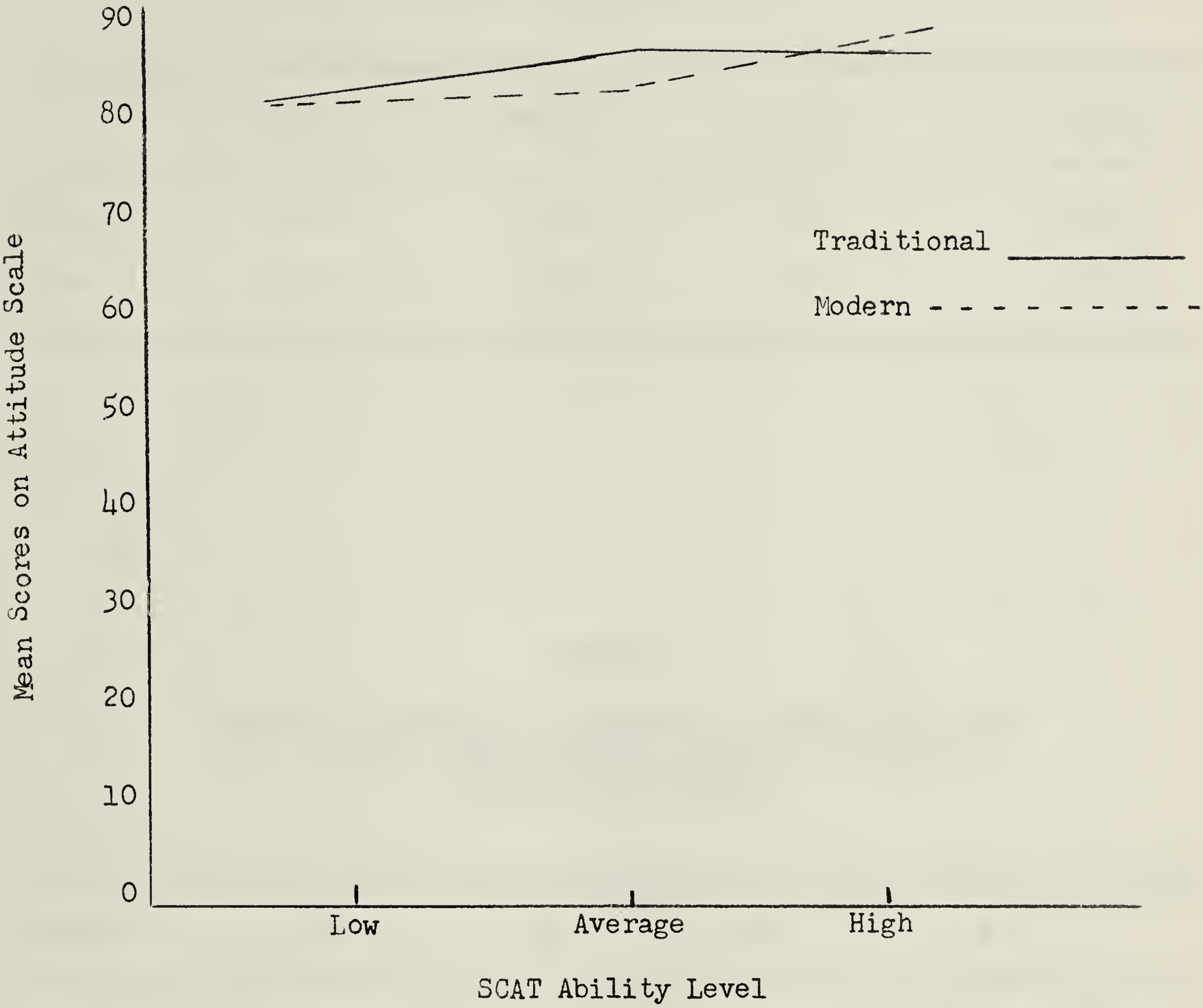

FIGURE 1

THE RELATIONSHIPS BETWEEN ATTITUDE SCALE CELL MEAN SCORES FOR THE TWO INSTRUCTIONAL GROUPS AT THE THREE SCHOLASTIC ABILITY LEVELS

TABLE IX

ATTITUDE SCALE CELL MEAN SCORES CLASSIFIED BY SEX AND MATHEMATICS PROGRAM

	Number	Modern	Number	Traditional
Girls	164	82.73	60	81.80
Boys	167	84.65	60	86.83

TABLE X

SUMMARY OF ANALYSIS OF VARIANCE -- UNWEIGHTED MEANS FOR ATTITUDE SCALE SCORES CLASSIFIED BY SEX AND MATHEMATICS PROGRAM

Source	SS	DF	MS	F	
Sex	1,064.83	1	1,064.83	5.89	$p < 0.02$
Program	34.34	1	34.34	0.19	$p < 0.66$
Interaction	213.27	1	213.27	1.18	$p < 0.25$
Within	80,788.02	447	180.73		

$F_{.05}\ (1,447) = 3.84$ $F_{.01}\ (1,447) = 6.63$

The results of the t statistics on the attitude scale cell means for boys and girls in the modern and traditional mathematics programs are as follows:

<u>Modern Mathematics</u>

$t_{\text{Boys vs Girls}} = .82$

<u>Traditional Mathematics</u>

$t_{\text{Boys vs Girls}} = 2.05$

$t_{.05}\,(447) = 1.65$

$t_{.01}\,(447) = 2.33$

The results of the preceding statistical procedure indicates there is no significant difference in attitude toward mathematics between boys and girls enrolled in a modern mathematics program. However, in the traditional mathematics program, the boys have a significantly more favorable attitude toward mathematics than the girls. The difference between the attitude scale cell means is significant at the .05-level with the boys having the higher cell mean. Therefore, Hypothesis 4 is partly supported and partly rejected by the statistical findings.

Figure 2 graphically illustrates the relationship between attitude scale cell mean scores for modern and traditional mathematics students when classified by sex. In this figure, the raw mean scores obtained from the attitude scale is plotted against sex, namely boys and girls.

<u>Hypothesis 6</u>

> There is a significant positive correlation between attitude toward mathematics and scholastic ability.

<u>Hypothesis 7</u>

> There is a significant positive correlation between attitude toward mathematics and problem solving skill.

Table XI, classifies the information and results of correlations for hypotheses six and seven. A one-tailed test was used to test for the

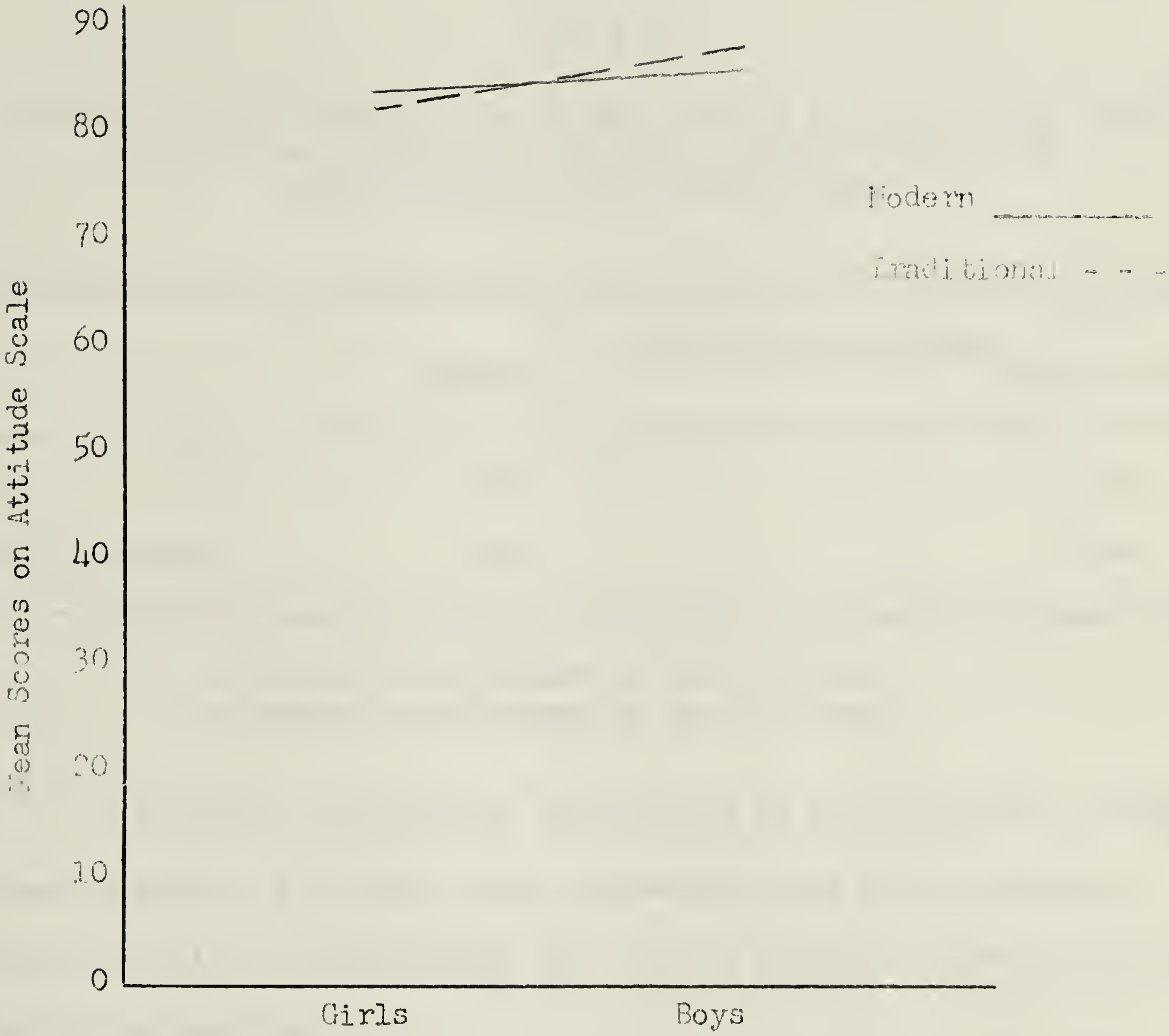

FIGURE 2

THE RELATIONSHIP BETWEEN ATTITUDE SCALE CELL MEAN SCORES FOR THE TWO INSTRUCTIONAL GROUPS CLASSIFIED BY SEX

significance of the correlations, since the direction of the relationship was stated in the hypothesis.

TABLE XI

PEARSON PRODUCT-MOMENT CORRELATIONS BETWEEN ATTITUDE SCALE SCORES IN THE TWO MATHEMATICS PROGRAMS AND SCAT SCORES AND PROBLEM SOLVING SCORES RESPECTIVELY

	Attitude Scale Scores	
	Modern	Traditional
SCAT	.18*	.18*
Problem Solving	.27**	.26**

* denotes significance at the .05-level.
** denotes significance at the .01-level.

A positive relationship, significant at the .05-level, exists between students' attitudes toward mathematics and their scholastic ability in both the experimental and control groups. Therefore, Hypothesis 6 is accepted.

Hypothesis 7 is also accepted, since the positive correlation between attitude toward mathematics and problem solving skill is significant at the .01-level for both the experimental and control groups.

SUMMARY

A one-way analysis of variance was used on the attitude scale scores to test for differences in attitude toward mathematics between modern and traditional mathematics students. No significant differences were found.

Comparisons were made between attitude scale means for the two mathematics groups at each of the three ability levels. Tests of statistical significance were carried out on these means by using a two-way analysis of variance -- unweighted means solution and by applying t-tests when appropriate. There was no significant difference between means of the modern and traditional mathematics groups at each of the three ability levels. Within the modern mathematics groups, the difference between the cell means of the high and average ability levels was significant at the .05-level and a .01-level of significance was found between the cell means of the high and low scholastic ability levels with the high ability groups having the larger attitude scale mean. Within the traditional mathematics group, only the cell means of the high and low ability levels were significant at the .05 level with the high ability group having the larger attitude scale mean. No significant difference was found between the other possible pairs of cell means.

A two-way analysis of variance -- unweighted means solution and t-tests were used to determine if significant differences exist between cell means for boys and girls in the two mathematics programs. The only significant difference found was between the cell means of boys and girls in the traditional mathematics program. The difference was significant at the .05-level with the boys having the higher cell mean.

Pearson product-moment correlations of .27 and .26 respectively were found between the attitude scale scores of modern and traditional mathematics students and their scores on the grade nine problem-solving section of the Iowa Tests of Basic Skills. Correlations of .18 were obtained between attitude scale scores and SCAT total scores for the two mathematics programs.

CHAPTER VI

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

REVIEW OF THE THESIS

The major aim of this study was to investigate and compare the attitudes toward mathematics of a group of modern mathematics students and a comparable group of traditional mathematics students at the grade nine level. The experimental group, consisting of three hundred thirty-one students, started taking modern mathematics in grade seven and continued with it in grade eight and nine. The text series they used were Seeing Through Mathematics and Exploring Modern Mathematics. The control group, consisting of one hundred twenty students, were not exposed to an organized curriculum of modern mathematics. Their texts were of the conventional type.

On the basis of SCAT test results, which were administered in September, 1963, it was concluded that the control and experimental groups were comparable in overall scholastic ability. A survey of teacher qualifications and characteristics indicated no major differences between the teachers involved in the two mathematics programs at the Junior High School level.

In the spring of 1965, the students involved in this study wrote the grade nine problem solving section of the Iowa Tests of Basic Skills and an attitude scale which was designed by the investigator. The purpose of the attitude scale was to determine the students' attitudes toward mathematics.

In order to test the hypotheses formulated, it was necessary to divide the students into approximately equal thirds on the basis of SCAT total scores. This resulted in three ability levels - high, average and low. The students were also classified according to sex and type of mathematics program.

The statistical procedures used to analyze the data were one-way analysis of variance, two-way analysis of variance-unweighted means solution, and the appropriate t-tests to determine if significant differences exist between means. The correlations carried out were based on the Pearson product-moment method. In the statistical analysis of the data gathered in this experiment, the difference between two mean scores was considered to be statistically significant if the probability of observing such a difference as a result of sampling error was .05 or less.

CONCLUSIONS

On the basis of the results of the statistical procedures carried out and subject to the limitations specified in Chapter I, the following conclusions were made.

There is no significant overall difference in attitudes toward mathematics between students enrolled in a modern mathematics Junior High School program and those students taking traditional mathematics at this level. This means it is possible to present a precise and rigorous modern mathematics curriculum to Junior High School students without any loss of a positive attitude towards mathematics.

At the three scholastic ability levels, no significant difference exists between students in the two mathematics programs in their attitudes

toward mathematics. From this one can conclude that modern materials may be used with students of average and low ability without an apparent loss of favorable attitudes. Within the bounds of each of the two mathematics programs, statistically significant differences exist between students in high and low ability levels in their attitude toward mathematics, with the high ability students having the more positive attitude. The writer concludes that a slightly positive relationship exists between attitude toward mathematics and scholastic ability. This conclusion is further supported by the .18 correlation coefficient obtained between the two variables.

No significant difference exists in attitude toward mathematics between girls in the experimental and control groups and between boys in the same two groups. However, it is interesting to note that the boys taking modern mathematics obtained an attitude scale mean of approximately two marks lower than the boys enrolled in traditional mathematics classes, while the modern girls' mean was approximately one mark higher than the mean of the traditional girls.

The studies reviewed in Chapter III tend to support the supposition that boys have a significantly more favorable attitude toward mathematics than girls. This holds true for the traditional mathematics students in the present study, but not for the modern mathematics pupils. In effect, the modern materials reduce the difference in attitude toward mathematics between boys and girls.

A positive relationship, significant at the .01 level, exists between attitude toward mathematics and problem solving skill for each of the two mathematics programs. The correlation for the modern mathematics students was .27 as compared to .26 for the traditional pupils. The two correlations are not significantly different.

Teacher responses from the teacher questionnaire indicated the teachers of the modern mathematics program found their students more interested in the subject than their counterparts in the old course. They claimed the students showed more enthusiasm for mathematics and derived greater satisfaction from the lessons than the students in the conventional mathematics program. The teachers found the new mathematics enjoyable to teach. They all preferred it to the traditional course.

In considering all the foregoing conclusions, one must keep in mind the limitations of the instrument used, since it was a critical factor in determining the findings of this study.

The reader is encouraged to scrutinize the items in the attitude scale to see if they do appear to measure attitudes toward mathematics. The writer feels each item contributes to the overall purpose of the attitude scale, since each item can be positioned in the framework of the internalization continuum. The investigator also invites the reader to examine carefully the methods used for validating the attitude scale and testing it for reliability. These methods are considered to be within the bounds of sound experimental research.

As noted previously, the attitude scale does not measure attitudes beyond the commitment level in the internalization continuum because of the difficulty in assessing attitudes with only a paper and pencil test

at the upper levels of the continuum. However, this is not a shortcoming of the attitude scale since the purpose of the instrument was to determine the attitudes of groups of individuals toward mathematics rather than determine the intensity of the attitude of a particular individual.

After considering all of the characteristics of the attitude scale, the investigator feels the instrument was sensitive enough to detect any difference in attitude toward mathematics that may have existed between the modern and traditional mathematics students.

IMPLICATIONS FOR FURTHER RESEARCH

One of the interesting by-products of this study and previous studies is the discrepancy existing between teacher perceptions of student attitudes toward the new mathematics materials and the results accruing from statistical studies. The teachers claim the students find the new materials much more enjoyable than the old; but the statistical studies indicate no significant difference in attitude toward mathematics. This phenomenon warrants study to determine why the discrepancy exists.

The present study only serves the purpose of overall comparisons of attitudes between modern and traditional mathematics students. There is a need for detailed studies which will consider the interrelationship among attitude, achievement, and scholastic ability. Do positive attitudes overcome a lack of aptitude for mathematics? Is attitude toward mathematics a better predictor of future success than scholastic ability? Does the discovery approach in teaching mathematics improve student attitudes? Studies involving the above variables should not only consider the mathematics program as a whole, but also its various aspects.

If we are to improve student attitude toward mathematics, we must know the major causes of negative attitudes. What is the influence of parents and teachers? Do attitudes change markedly from year to year? What grade levels appear to be most crucial in attitude development? Many educators insist that a positive attitude toward a school subject is vital for effective learning. If this is true, then the above questions would appear to be of vital importance in any mathematics education program.

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APPENDIX A

TEACHER'S GUIDELINE

Your evaluation of the students' attitudes toward mathematics is needed for the validation of the attitude scale. To help make your observations more objective a guideline has been prepared. On the basis of these observations, opinions that the students may have expressed, and any other knowledge you may have, please rate each student on a 5 point scale with 5 indicating the most favorable attitude and 1 the least favorable.

1. Contributes to group discussion by asking throught-provoking questions or supplying relevant information and ideas.

2. Finds pleasure in doing mathematical puzzles and in playing real number games.
   - brings puzzles and number games to school.

3. Desire and interest in learning mathematics.
   - attentive in class.
   - homework and classwork completed neatly and carefully.
   - doesn't wait until last minute to complete assignments.

4. Willingness to spend time, energy, attention to build insight, creativity, discovery beyond the requirements of the course.
   - suggests and works out alternative methods for problems.
   - does extra reading on his own.
   - solves optional problems.
   - brings mathematical problems to school.

5. Will study mathematics because he enjoys it, he gets satisfaction from knowing mathematical idea, he feels rewarded when he attains mathematical competency.
   - takes pride in his work.
   - doesn't "give up" quickly when solving a difficult problem.
   - appreciates a logical proof.

6. Curiosity about the unique structure of mathematics and a continuing desire to understand the structure of mathematics.
   - wants to know "why" and not just "how".
   - strives for precision and a logical order in his proofs.
   - detects weaknesses and proofs lacking a logical order.
   - discusses mathematical ideas and concepts with his friends.

APPENDIX B

PILOT STUDY VERSION OF ATTITUDE SCALE

A MATHEMATICS STUDY

The best answer to each statement is your own first impression. There are no right or wrong answers. Think carefully, but do not spend too much time on any one question. Let your own personal experience guide you to choose the answer you feel about each statement.

Please mark every item

1. I find most mathematics lessons:

    a) extremely interesting.
    b) quite interesting.
    c) interesting.
    d) not very interesting.
    e) not interesting at all.

2. A knowledge of mathematics for any job at all is

    a) most important.
    b) very important.
    c) quite important.
    d) of small importance.
    e) not important.

3. If I did not have to take mathematics, I would like school:

    a) much less.
    b) a little less.
    c) same as now.
    d) a little better.
    e) much better.

4. Mathematics is:

    a) the most important subject.
    b) one of the more important subjects.
    c) just as important as any other subject.
    d) not as important as some of the other subjects.
    e) the least important subject.

5. I find problem solving:

    a) extremely interesting.
    b) quite interesting.
    c) interesting.
    d) not very interesting.
    e) not interesting at all

6. When I h a difficulty with a new topic in my mathematics course, I ask my teacher to clarify the section:

 a) very frequently.
 b) frequently.
 c) sometimes.
 d) hardly ever.
 e) never.

7. If books about mathematics were available, I would:

 a) read most of them.
 b) read some of them.
 c) look at the diagrams and pictures.
 d) page through some of them.
 e) never look at them.

8. If someone says mathematics classes are worthless and a waste of time, I would:

 a) strongly disagree.
 b) tend to disagree.
 c) not take a side.
 d) tend to agree.
 e) strongly agree.

9. When I do my homework, my mathematics is:

 a) always done first.
 b) often done first.
 c) usually done first.
 d) sometimes done first.
 e) never done first.

10. I find mathematical puzzles:

 a) extremely interesting.
 b) quite interesting.
 c) sometimes interesting.
 d) not very interesting.
 e) not interesting at all.

11. I would be interested in taking other subjects that make use of:

 a) a great deal of mathematics.
 b) quite a bit of mathematics.
 c) some mathematics.
 d) a little mathematics.
 e) no mathematics.

12. When I have difficulties with my mathematics course, my parents:

    a) always encourage me.
    b) often encourage me.
    c) usually encourage me.
    d) sometimes encourage me.
    e) never encourage me.

13. If given the opportunity to join one of the following clubs, I would prefer a:

    a) mathematics club.
    b) science club (physics).
    c) science club (chemistry).
    d) science club (geology).
    e) literary club.

14. If I listed the following subjects in order of preference, my first choice would be:

    a) mathematics.
    b) science (physics part).
    c) science (chemistry part).
    d) science (geology part).
    e) English.

15. If I could receive one of the following for a year, I would pick:

    a) a mathematics magazine for high school students.
    b) a science magazine for high school students.
    c) a popular science magazine.
    d) a geology magazine for high school students.
    e) a literary magazine for high school students.

16. In my mathematics course, I take notes as the teacher explains new material:

    a) always.
    b) often.
    c) usually.
    d) sometimes.
    e) never.

17. When I study my mathematics course, I most often:

    a) make written summaries of the sections covered.
    b) do additional problem solving.
    c) do many drill questions.
    d) memorize the formulas given in the text.
    e) look over some work previously done.

18. If I listed my courses in order of preference, I would place mathematics:

    a) first.
    b) second.
    c) third.
    d) fourth.
    e) fifth.

19. Whenever mathematical word problems are presented to us, I get:

    a) a great deal of satisfaction in working them out.
    b) quite a bit of satisfaction in working them out.
    c) some satisfaction in working them out.
    d) very little satisfaction in working them out.
    e) no satisfaction in working them out.

20. My mathematics course has made:

    a) mathematics enjoyable for me.
    b) mathematics a pleasant course.
    c) me feel indifferent towards mathematics.
    d) mathematics classes an uncomfortable experience for me.
    e) me strongly dislike mathematics.

21. I feel my mathematics teacher:

    a) enjoys teaching mathematics.
    b) gets some pleasure in teaching mathematics.
    c) gets some satisfaction in teaching mathematics.
    d) neither likes or dislikes teaching mathematics.
    e) dislikes teaching mathematics.

22. When I do my mathematics homework, I am usually:

    a) extremely interested.
    b) interested.
    c) somewhat interested.
    d) not too interested.
    e) not interested at all.

23. If I do not understand a concept or idea which was presented in my mathematics class, I:

    a) refer to the notes I took in class.
    b) refer to my textbook.
    c) ask my teacher.
    d) ask a friend.
    e) do nothing about it.

24. When we start a new topic in mathematics, I am usually:

a) keenly interested.
b) interested.
c) somewhat interested.
d) not too interested.
e) not interested at all.

25. When my teacher takes up new work in class, he appears to be:

a) very sure of himself.
b) quite sure of himself.
c) sure of himself.
d) not too sure of himself.
e) very unsure of himself.

26. The average amount of time I spend on homework assignments in mathematics takes the following time per day:

a) more than one hour.
b) 3/4 to one hour.
c) 1/2 hour to 3/4 hour.
d) 1/4 hour to 1/2 hour.
e) 0 hours to 1/4 hours.

27. When I get an assignment in mathematics:

a) I do it immediately.
b) I do it eventually.
c) I may get it done.
d) I put it off as long as possible.
e) I don't do it.

28. If it was possible for me to go to University, I would:

a) take as many mathematics courses as I could.
b) take a few mathematics courses.
c) take only one course in mathematics.
d) take courses which make use of mathematics.
e) stay clear of mathematics courses.

29. Most of my work in this class is done:

a) to satisfy my curiosity about mathematics.
b) to gain competence in mathematics.
c) to get a good mark.
d) to just pass the class.
e) to put in the time alloted to mathematics.

30. During mathematics lessons, I feel:

a) extremely confident in myself.
b) quite confident in myself.
c) confident in myself.
d) a little unsure of myself.
e) very unsure of myself.

APPENDIX C

TEACHER COMMENTS

In April, 1965, the Alberta Junior High School Mathematics Sub-Committee asked the teachers involved in the experiment to complete a questionnaire. Teacher comments to those questions related directly or indirectly to this study are presented in this section. These questions are applicable only to teachers teaching the modern mathematics program.

The comments of STM and EMM teachers will follow each question asked. Each point entered under the question will represent one teacher's comments.

Question 1

Did you find that there was more, or less, interest shown by the students for this program than in the authorized course, or did it appear to you that the degree of interest was about the same?

Comments From STM Teachers

1. Interest seemed greater because of the completely new ideas contained in the course.

2. Definitely more interest.

3. It appears to me that my students definitely have more interest.

4. There was a majority, say two-third of the pupils, that showed more interest than they would have in the authorized course.

5. There was much more interest. On the whole, in Grade 7, 8 and 9 STM course, I found absolutely no discipline problems. The pupils are eager, and the top students are actually reading mathematics books.

Comments From EMM Teachers

1. The better students showed considerable interest - some branched off on their own into calculus etc., reading books and discussing various topics with me. To the slower students, math is math!

2. Interest is about the same. This is a serious indictment of the course. It should be much more interesting to students. The emphasis on under-

standing has been carried too far; the application of such material is not apparent to most students.

Question 2

If your class appeared more interested, to what do you attribute this interest? Was it due to the novelty of doing something different from other classes, or was it because the students found the material relatively easy, or relatively challenging? Were they interested in a new approach to similar problems, or were they stimulated by the type of activity required?

Comments From STM Teachers

1. (a) Found the material challenging.
   (b) Knowing the why, not only the how.
   (c) Found that math. is exciting and "fun", compared to the boredom of rote learning.

2. Pupils were interested in a new approach. Many of the best pupils mentioned that until Gr. VIII and STM they had no interest in mathematics; it was their worst subject, now their best. They mentioned a keen interest and a desire to learn more in Gr. X.

3. Of the four classes that I teach, three of them found the course most challenging and felt a sense of achievement. Also, it is because of my interest and enthusiasm which was made apparent to me through a survey which I conducted.

4. The challenge, progressive development and achievement resulted in more and better interest on the part of the class.

5. They seemed interested because they were doing something different; they were interested in the new ideas presented; they were interested in the new approach given to similar problems.

Comments From EMM Teachers

1. This class has been on this program for 3 years. Any interest due to novelty, etc. has long disappeared. They accepted this as the course to take; not easy for any, and rather difficult at times for the slower student. They had no basis for comparing it with any other course. Generally, they were interested in the topics, the approach was effective, and they worked well.

Question 3

If you have found that your class has shown less interest than in the

authorized course, to what do you attribute this attitude? Did the students find the material too easy or difficult? Was it not sufficiently useful or practical? Was it due to a lack of background?

Comments From STM Teachers

1. Where the preciseness was not demanded in Gr. 7, an attitude of discouragement was evident and took most of this year to overcome.

2. One class   far less interest due to a poor background. They are most confused and a real attitude of discouragement is present.

3. I feel that those who showed less interest may have no matter what course was presented. However, the course proved too difficult because there weren't enough areas where they could "shine", thus gaining some feeling of "doing" or "belonging".

Comments From EMM Teachers

1. It was not sufficiently useful or practical. The students could not appreciate where it was leading to, what the purpose of it all was. It should be possible to write a good vigorous math. textbook which teaches math. in the manner of this book but also gives a sense of purpose and usefulness.

2. Since the problems were difficult for the most part, it did not give the pupils a sense of achievement.

Question 4

If in a previous school year you used in part or in total a different "modern" mathematics course, please compare pupil interest.

Comment From A STM Teacher

I used the authorized text in Gr. IX in '63-64. There wasn't much interest shown at all. Most of that class had been on STM in VII and VIII and found to be "let down" in Gr. IX. It seemed they only worked toward a final exam because they had to.

Comment From an EMM Teacher

The Grade 7 EMM course has more interesting topics than does the 8 or 9 EMM course; more natural interest was evident. Grade 7 EMM and STM courses are equally interesting. The Grade 8 and 9 books seem to lose this appeal.

The last part of the questionnaire, entitled "Additional Comments,"

solicited teacher reactions to the new mathematics programs. All but two of the teachers indicated they enjoyed teaching the new courses. They felt the students were enthusiastic about the new materials and enjoyed studying them. The teachers felt the students, in general showed more interest in the modern mathematics than their counterparts did in the conventional course.